ENVIRONMENTAL MONITORING PROGRAM

Plan of Study

Shell Outer Continental Shelf Lease
Chukchi Sea, Alaska

August 2013

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ACRONYMS AND ABBREVIATIONS

ADCP ....acoustic Doppler current profiler
Ag ....silver
Al...........................aluminum
AMAR....................autonomous multichannel acoustic recorder
ANIMIDA ....Arctic Nearshore Impact Monitoring In Development Area
Ba ....barium
bbl/hr ....barrels per hour
Be ....beryllium
BOP ....blowout preventer
cANIMIDA ....Continuation of Arctic Nearshore Impact Monitoring In Development Area
Cd ....cadmium
CFR ....Code of Federal Regulations
cm ....centimeter
CoC ....chain of custody
COMIDA CAB ....Chukchi Sea Offshore Monitoring In Drilling Area: Chemical and Benthos
Cr...........................chromium
CSESP ....Chukchi Sea Environmental Studies Program
CTD.......................conductivity, temperature, depth
Cu ....copper
DMP ....discharge monitoring program
DMR ....discharge monitoring report
EMP ....environmental monitoring program
EPA .......................U.S. Environmental Protection Agency
Fe...........................iron
ha ....hectacre
Hg ....mercury
IC_{50} ....inhibitory concentration that impacts 50% of a population
IHA ....Incidental Harassment Authorization
kg/m^2 ....kilograms per square meter
LOQ ....limit of quantitation
m ....meter
m^2 ....square meter
mg/Kg ....milligrams per kilogram
mg/L ....milligrams per liter
MLC ....mudline cellar
mm ....millimeter
MMPA ....Marine Mammal Protection Act
MQO ....Measurement Quality Objective
NPDES ....National Pollutant Discharge Elimination System
OBS ....optical backscatter sensor

OCS ....outercontinental shelf
OOC Model ....Offshore Operators Committee Mud and Produced Water Discharge Model
OSI ....organic sediment index
PAH.....................polycyclic aromatic hydrocarbon
Pb ....lead
PERF ....Petroleum Environmental Research Forum
PSO ....protected species observer
PTD ....proposed total depth
QAPP ....Quality Assurance Project Plan
QA ....quality assurance
QAU ....quality assurance unit
QC ....quality control
ROV ....remotely-operated vehicle
Sb ....antimony
SHC ....saturated hydrocarbon
SOP ....standard operating procedure
SPI ....sediment profile imaging
SPP ....suspended particulate phase
TAH ....total aromatic hydrocarbons
Ti ....titanium
TOC......................total organic carbon
TPH ....total petroleum hydrocarbons
TSS ....total suspended solids
VOC ....volatile organic compound
WBM....................water-based mud
WET ....whole effluent toxicity
Zn ....zinc

1. INTRODUCTION

This document presents the environmental monitoring program (EMP) plan of study to be conducted at the discharge monitoring area within Shell Gulf of Mexico Inc. (Shell) Burger prospect lease blocks in the outer continental shelf (OCS) of the Chukchi Sea, Alaska, during and following exploratory drilling operations (Figure 1). The EMP presented in this document follows the stipulations presented in the *Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES) for Oil and Gas Exploration Facilities on the Outer Continental Shelf (OCS) in the Chukchi Sea, permit number AKG-28-8100* issued by the U.S. Environmental Protection Agency (EPA) in compliance with the Clean Water Act.

1.1. EMP Goal and Objectives

The goal of the EMP is to outline the sampling rationale and approach to collect high quality environmental data, during four discrete time phases, in order to support future permit development and to validate the determination that impacts from authorized Arctic offshore oil and gas exploration discharges will not cause an unreasonable degradation of the marine environment.

The objectives of the EMP, consistent with the NPDES authorization are:

1. Complete an initial site assessment, including a physical sea bottom survey, to ensure the exploratory facility is not located or anchored in a sensitive biological area or habitat;
2. Evaluate water quality characteristics of the receiving water and potential effects of the specified discharges;
3. Evaluate sediment characteristics of the seafloor and potential effects of the discharges on the sediment characteristics;
4. Evaluate potential effects to the benthic community structure due to deposition of Discharge 001 (water-based drilling fluids and drill cuttings) and Discharge 013 (muds, cuttings and cement at the seafloor), which includes both spatial and temporal changes in community diversity and abundance; and
5. Evaluate the suspended particulate and dissolved constituent plume(s) in the vicinity of the discharges.

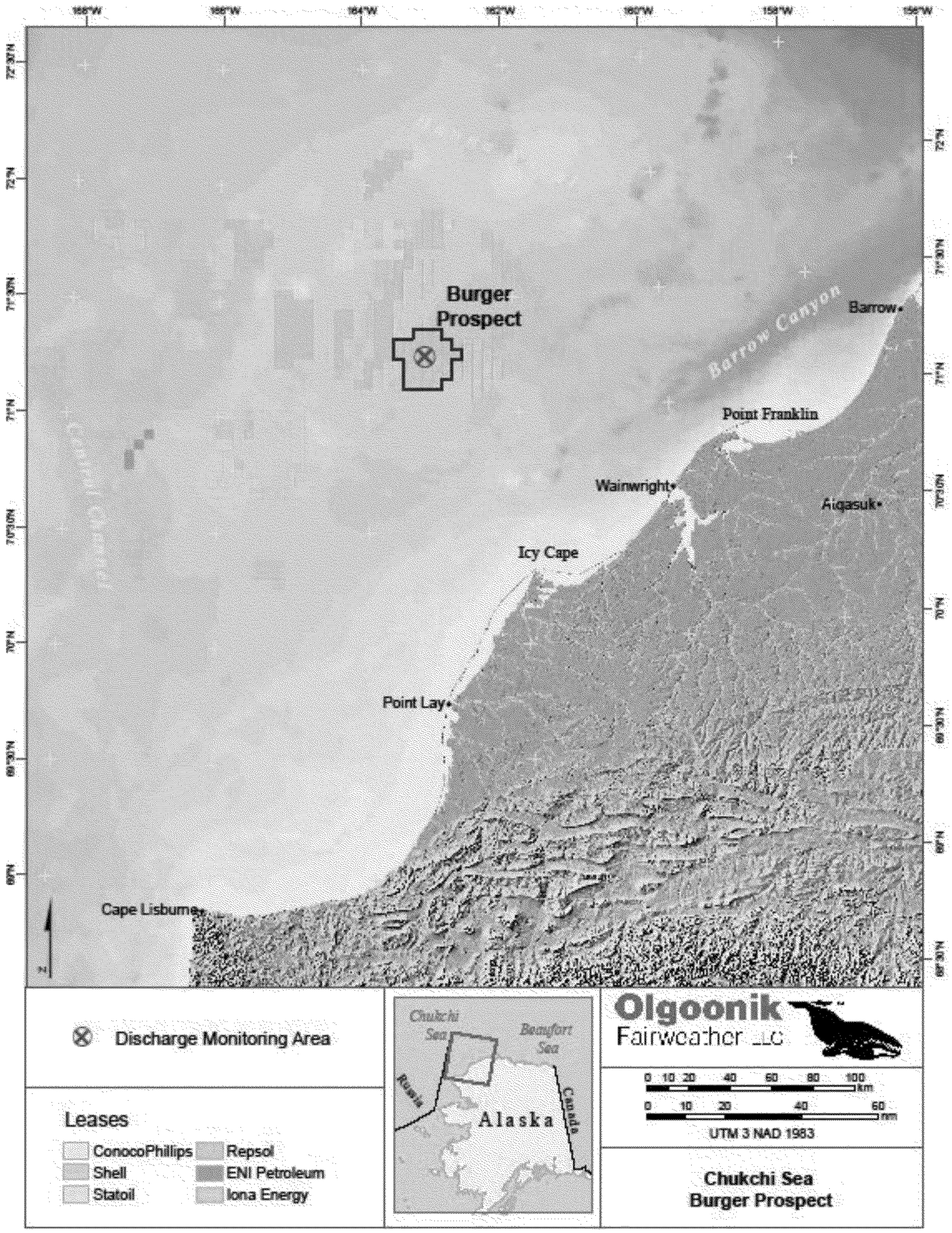

Figure 1: Chukchi Sea Burger prospect.

1.2. Authorized Discharges

A variety of waste streams are authorized under the NPDES permit, which includes 13 different discharges (Table 1).

Table 1: Summary of authorized discharges by number and description.[1]

Discharge Number	Description
001	Water-based Drilling Fluids and Drill Cuttings
002	Deck Drainage
003	Sanitary Wastes
004	Domestic Wastes
005	Desalination Unit Wastes
006	Blowout Preventer Fluid
007	Boiler Blowdown
008	Fire Control System Test Water
009	Non-contact Cooling Water
010	Uncontaminated Ballast Water
011	Bilge Water
012	Excess Cement Slurry
013	Muds, Cuttings and Cement at the Seafloor

[1]In the event that a particular discharge is not released, the requirements associated solely with that discharge will not be conducted

The discharges represent operational discharges resulting from normal drilling activities, such as sanitary and domestic wastes and desalination unit wastes (e.g., released from generation of drinking water), and discharges specific to drilling activities, specifically muds and cuttings.

2. BACKGROUND

Shell plans to drill several exploratory wells on the Chukchi Sea OCS in accordance with plans submitted to the U.S. Department of Interior. The predicted average drilling season is long enough to drill two or three exploration wells from spud to proposed total depth (PTD) and possibly construct an additional mudline cellar (MLC) or drill and secure a partial well.

2.1. Chukchi Sea Site Description

The OCS area of the Chukchi Sea is among the least-developed continental shelf areas in the United States. The Chukchi Sea is north of the Bering Sea and west of the Beaufort Sea, and borders numerous Alaska Native villages along the northwestern coast of Alaska (e.g., Wainwright, Barrow). The portion of the Chukchi Sea where oil exploration is intended is north of 70°N latitude (Figure 1). Both the Chukchi and Beaufort Seas were explored in the late 1980s and early 1990s for potential oil and gas development and have been further characterized in recent years following lease sales in 2005, 2007 and 2008. The location of the Chukchi Sea north of the Arctic Circle makes field work and data collection challenging, due to its remoteness, cold temperatures, and presence of sea ice for most of the year.

OCS Lease Sale 193 was held in February 2008 and Shell was subsequently awarded 275 leases (blocks) through a competitive bidding process. The locations of the lease blocks in the Burger Prospect and the drill sites addressed in this EMP are indicated in Figure 2. Water depth in this part of the OCS is shallow, ranging from 40- to 50-meters (m) deep. Predominant wind direction is from the northeast. Tides range from 5 to 30 centimeters (cm). Predominant water flow direction has been measured to the east-southeast, however weather conditions can be highly variable, with storms that result in significant wind-driven water surface currents in any possible direction. Due to the fact that the area is covered by sea ice much of the year, the exploration drilling and monitoring activities are anticipated to occur during the open-water season.

2.2. Chukchi Sea Drilling Operations

Currently, Shell plans to drill up to six wells to PTD in the Burger prospect using a drill rig. The drill rig will be attended by a fleet of support vessels, including roles for ice management, anchor handing, refueling, resupply and oil spill response. Table 2 lists possible drill site locations.

Table 2: Possible drill site locations in the Burger prospect.

Prospect	Well	Area	Block	Lease Number	Coordinates (m)		Latitude	Longitude
					X	Y		
Burger	A	Posey	6764	OCS-Y-2280	563945.26	7912759.34	N71°18'30.92"	W163°12'43.17"
Burger	F	Posey	6714	OCS-Y-2267	564063.30	7915956.94	N71°20'13.96"	W163°12'21.75"
Burger	J	Posey	6912	OCS-Y-2321	555036.01	7897424.42	N71°10'24.03"	W163°28'18.52"
Burger	R	Posey	6812	OCS-Y-2294	553365.47	7907998.91	N71°16'06.57"	W163°30'39.44"
Burger	S	Posey	6762	OCS-Y-2278	554390.64	7914198.48	N71°19'25.79"	W163°28'40.84"
Burger	V	Posey	6915	OCS-Y-2324	569401.40	7898124.84	N71°10'33.39"	W163°04'21.23"

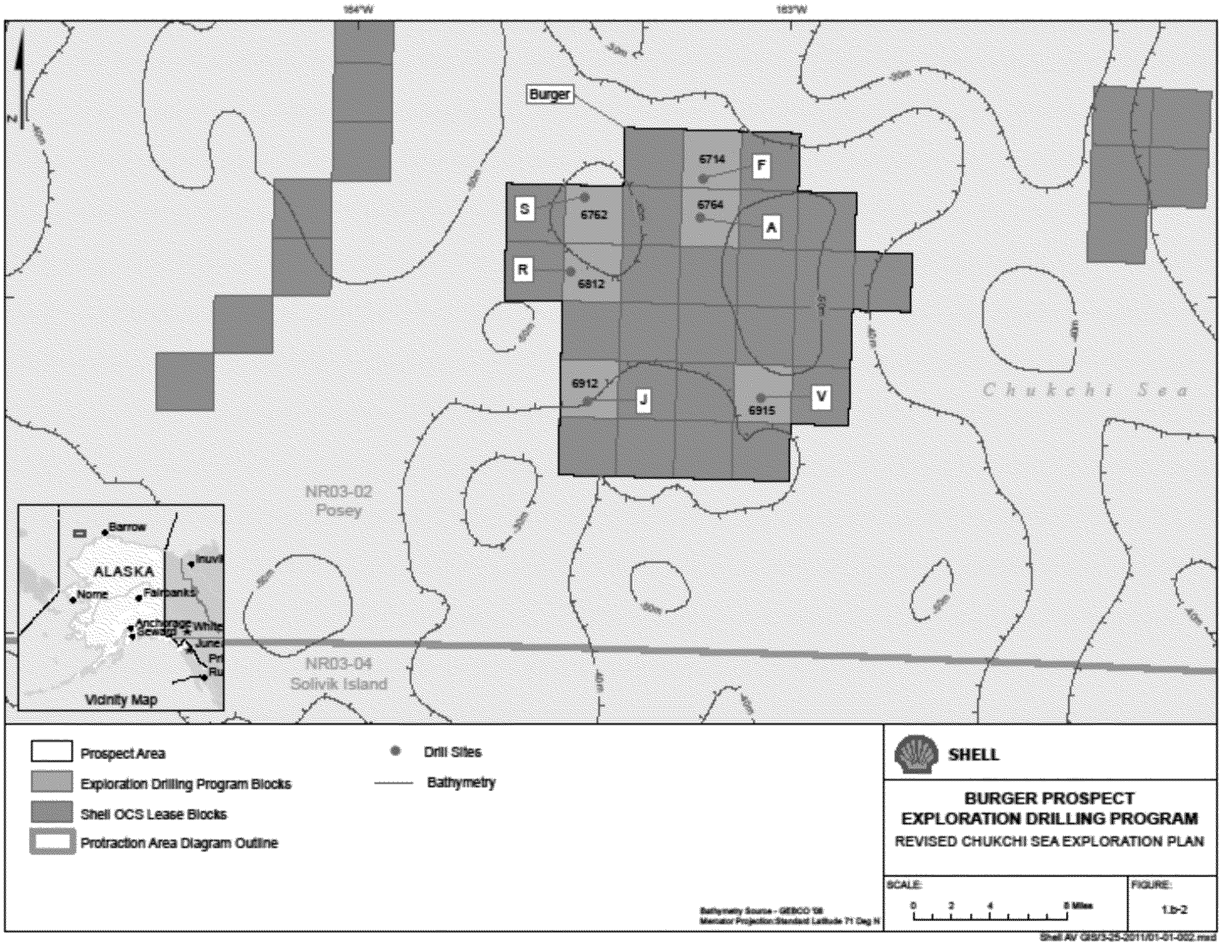

Figure 2: Burger prospect exploration drilling program.

2.2.1. Drilling Operations

Well drilling operations begin with the creation of a tophole. A tophole consists of the foundational hole section(s) drilled prior to installing a blowout preventer (BOP) stack. The design also includes a slim pilot hole to evaluate the site for shallow hazards and a self-supporting MLC. The MLC is drilled in such a manner as to create a subsurface space that is approximately 20 feet in diameter and 40 feet deep. This space is used to house the wellhead, casing and blowout protectors, and protect them from damage during ice gouge events. The precise configuration of casing and hole sizes, depths and supporting hole sections will vary as the well design is matured and optimized.

During the drilling of the tophole, drill cuttings will be deposited at the seafloor. During cementing of casing strings, spacer and cement will be deposited on the seafloor and/or on the bottom of the MLC.

After the tophole is completed, drilling is advanced through a BOP and marine riser. Drilling mud and cuttings are transported up the riser to the drilling unit. There the cuttings are separated from the drilling fluid by solids control equipment. The separated solids are discharged into the sea and the reclaimed mud is recirculated downhole.

After prolonged drilling, the drilling fluid properties degrade through exposure to high temperatures and pressures in the well and by dilution with water and clay-sized cutting particles. At that point, a portion of the drilling fluid in the mud tanks may be discharged to the ocean to allow for mud reformulation.

2.2.2. Mud Formulation

Shell plans to use water-based mud (WBM) as a drill-flushing medium. Due to the very limited environmental impact of WBMs, which have low toxicity characteristics (Neff 2010, Petroleum Environmental Research Forum [PERF] 2005), WBMs are an authorized discharge (001 and 013) under the NPDES permit for the OCS Chukchi Sea.

The primary purposes of drilling mud are to cool and lubricate the drill bit, remove cuttings, and maintain pressure and formation stability (Neff 2010). The mud is formulated to suit the nature of the formation being drilled, plus factors such as depth, temperature and pressure. As the borehole is advanced to its PTD, progressively more complex mud formulations may be used to control the properties of the drilling fluid, which is continually reconditioned and recirculated back down the drill string. Various additives are used to improve the properties of the drilling fluid such as density enhancers, fluid loss reducers, viscosity agents, lubricants, dispersants and shale reactivity inhibitors. Other additives may include biocides, oxygen scavengers and corrosion inhibitors. Specific details on the water-based muds to be used for the exploratory drilling in the Burger prospect can be found in the drilling fluids plan.

The ingredients of a typical water-based drilling mud include brine, fresh water, barite (barium sulfate [$BaSO_4$]), inhibitors and biopolymers. Agents such as barite are added to increase mud weight and counterbalance downhole pressures at depth. Small volumes of mud are periodically discharged in bulk and replaced with seawater to control the rheological properties of the fluid.

Heavy metals such as copper (Cu), lead (Pb) and zinc (Zn) may be found in trace concentrations in drilling muds; however, these elements do not readily bioaccumulate (Neff 2010). Although the used mud could potentially contain various other additives, these materials represent only a small fraction of the overall mud volume (Neff 2008, Neff 2010). Most WBM additives are not bioavailable, are non-toxic, and/or are used in such small amounts that they are not present in used drilling fluids at concentrations high enough to contribute significantly to whole-mud toxicity (Trefry and Smith 2003, Neff 2008). The entire mud formulation goes through extensive toxicity testing and is verified to meet EPA's toxicity requirements (EPA 1993, EPA 2000, EPA 2006, EPA 2012, EPA 2013). The results of these toxicity tests are presented in the drilling fluids plan.

The manner in which the drill rig is operated and the nature of geological formations may contribute chemical constituents to the mud as the borehole is advanced vertically through the natural stratigraphic sequence. Once the reservoir target depth is reached, crude oil, condensate or gaseous hydrocarbons may become entrained in the mud. In samples of WBMs used in 2012, all metals were at or below background concentrations (i.e., average Chukchi Sea sediment concentrations) with the exception of barium (Ba), antimony (Sb), Cu, and Pb (Table 3). However, these metals generally are bound to clays or humates which limits their bioavailability. Similarly, hydrocarbons also typically exhibit limited bioavailability.

Note Cd and Hg concentrations in the stock bentonite sample and the three stock barite samples (reported as an average) were below the 3mg/kg and 1mg/kg effluent limitation requirements stipulated for discharge 001 (WMBs and drill cuttings).

Table 3: Metal concentrations in stock barite and bentonite used for Shell 2012 Chukchi Sea exploratory drilling activities.

Metal	Bentonite Concentration[1] (mg/Kg)[n=1]	Average Barite Concentration[1] (mg/Kg) [n=3]	Average Chukchi Sea Sediment Concentrations[2] (mg/Kg)
Aluminum (Al)	9800	829	50,000
Antimony (Sb)	0.0961	7.9	0.62
Arsenic (As)	1.89	15.5	14.6
Barium (Ba)	2190	2373	591
Beryllium (Be)	1.78	0.133	1.2
Cadmium (Cd)	0.705	1.43	0.17
Chromium (Cr)	4.32	11.0	72
Copper (Cu)	8.94	82.2	14
Iron (Fe)	8050	10200	29,000
Lead (Pb)	37.3	124	11
Mercury (Hg)	0.124	0.522	0.032
Nickel (Ni)	3.19	10.0	25
Selenium (Se)	0.46 (U)[3]	1.03	0.74
Silver (Ag)	0.114	0.330	0.12
Thallium (Tl)	0.0698	0.113	0.41
Tin (Sn)	1.6	0.965 (U)[4]	1.4

Metal	Bentonite Concentration[1] (mg/Kg)[n=1]	Average Barite Concentration[1] (mg/Kg) [n=3]	Average Chukchi Sea Sediment Concentrations[2] (mg/Kg)
Titanium (Ti)	78.5	13.4	(6,000)[5]
Zinc (Zn)	32.7	105	72

[1]Bentonite and barite analysis by method SW6020 (ICP-MS).
[2]Average Chukchi Sea sediment concentrations from Trefry et al. (2012).
[3]Selenium concentration in bentonite sample was analyzed for, but was not detected. Value reported represents limit of quantitation (LOQ).
[4]Tin concentrations in barite samples were analyzed for, but were not detected. Average value reported represents the averaged LOQ for three samples.
[5]Concentrations reported in parenthesis are estimated concentrations.
mg/Kg = milligrams per kilogram

2.2.3. Discharge Streams

Anticipated drilling discharge streams from the drill rig are listed in the Notice of Intent. Muds and cuttings discharges do not occur continuously and are typically intermittently discharged during drilling operations.

During drilling, there will be a few bulk WBM discharges over varying time periods. These brief WBM discharges and the more frequent, lower-rate discharges of drill cuttings will be released about 6 m below the sea surface after dilution in the disposal caisson. Depending on prevailing oceanographic conditions, these discharges may or may not be visible from the rig or any vessels in the vicinity. The WBM and cuttings plumes will dilute to background levels downstream of the rig, mainly through the settling of drilling mud and cuttings solids onto the sea floor (Neff 2010).

The major drilling discharge will be drill cuttings. The cuttings consist primarily of inert solids, such as crushed rock, Ba, and bentonite clay that settle rapidly to and accumulate on the sea floor down-current of the rig. When discharged to the ocean, WBM and drill cuttings, which are slurries of particles of different sizes and densities in water containing dissolved inorganic salts and organic chemicals, form a plume that dilutes rapidly as it drifts away from the discharge point with the prevailing water currents (Figure 3).

The WBM discharge undergoes dispersion, dilution, dissolution, flocculation and settling in the water column. All components in the WBM and cuttings discharges are diluted many-fold during descent through the disposal caisson. Most dissolved components, such as sodium chloride, in the WBM or cuttings plume exiting the disposal caisson, continue to dilute rapidly by turbulent mixing (eddy diffusion) of the receiving waters (Neff 2010). Particles in the plume also dilute and are dispersed in different ways depending on their sizes and densities. The WBM and cuttings plumes are expected to partition into two phases: (1) a dense, rapidly-settling particulate solids phase (~90% of total mass of mud and cuttings solids), and (2) an upper-water-column, slowly-settling phase containing fine-grained (clay-size) particles and dissolved ingredients of the discharge (~10% of total mass; Neff 2010). Because of the shallow water depth at the drill sites and the distance between the bottom of the disposal caisson and the seafloor, the two plumes will be co-mingled, with the larger, denser particles settling to the sea floor nearer to the rig than the fine particles. Fine-grained particles (clays) in the upper plume will remain suspended at or below the discharge depth (the plume water will have a salinity and density similar to or higher than that of the ambient seawater) or settle slowly and be carried away in the direction of the mid-depth residual currents (toward the east). It is unlikely that the upper plume will rise into surface waters (upper 10 m).

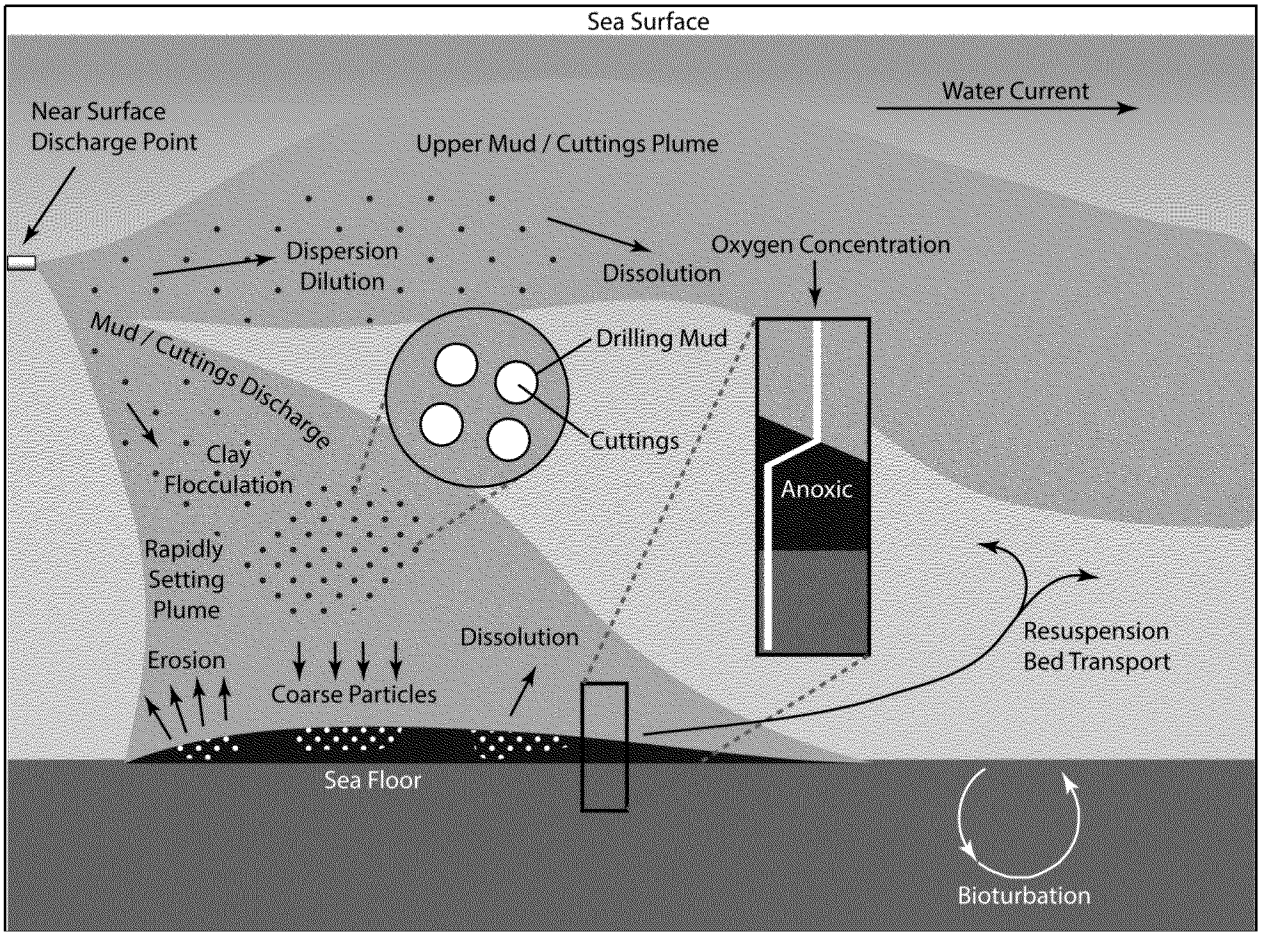

Figure 3: Dispersion and fates of WBM and cuttings following discharge to the ocean (Modified from Neff 2010). The WBM often forms 2 plumes, an upper plume containing fine-grained unflocculated solids and dissolved components of the mud, and a lower, rapidly-settling plume containing dense, larger-grained particles, including cuttings, and flocculated clay/barite particles.

The denser particles in the settling plume will sink quickly as they drift away from the discharge site, with the rate of sinking depending on particle size and density relative to seawater density at different depths in the water-column. The density of seawater increases with increasing depth (pressure) and salinity and with decreasing temperature. The continuous phase of both the gel WBM that will be used to drill the wider (upper) hole and the inhibitive polymer WBM that will be used to drill the narrower (deeper) sections of the well is a sodium chloride brine that will be denser than seawater; thus, the WBM plume will sink. WBM and cuttings particles may accumulate at a water depth where the density of the water and particles is the same.

2.2.4. Modeling Results

This section will be revised to reflect the updated Offshore Operators Committee Mud and Produced Water Discharge Model (OOC Model) results. The updated model report was sent to the EPA on August 1, 2013.

The modeling results are based on the depositional dynamics expected for exploratory drilling discharges in the Chukchi Sea. Research based on empirical field measurements of metals and other chemical components associated with drilling activities corroborates the model results and demonstrates that the majority of the deposition of muds and cuttings typically occurs within 250 to 500 m or less from the discharge location (Trefry et al. 2013) and that discharge impacts are limited in time and space (The Research Council of Norway 2012, Trefry et al. 2013). This information was used in developing the technical approach and scope.

3. OVERALL TECHNICAL APPROACH AND SCOPE

The EMP sampling design and detailed scope of work, necessary to achieve the monitoring objectives, is organized into 4 assessment phases (I, II, III, and IV) as illustrated in Table 4.

Table 4: Summary of four phases for implementation of the EMP.

Phase	Component
I	Baseline site characterization
II	During active drilling
III	Post-drilling
IV	No later than 15-months after drilling operations cease at a drilling site

The Phase I assessment requires a physical site characterization which includes:

1. An initial site physical sea bottom survey;
2. Physical characteristics;
3. Receiving water chemistry and characteristics, and
4. Benthic community structure.

The Phase II assessment will be conducted during drilling activities and includes:

1. Effluent toxicity characterization;
2. Discharge 009 (non-contact cooling water) plume observations;
3. Water-based drilling fluids/drill cuttings metals and hydrocarbon analysis; and
4. Plume monitoring and observations.

Phase III and IV assessments are conducted following the cessation of drilling activities at a drilling site. Phase III components will be conducted as soon as practicable immediately after drilling and include:

1. Physical sea bottom survey;
2. Sediment characteristics and discharge effects; and
3. Benthic community bioaccumulation monitoring.

Phase IV assessments will be conducted no later than 15 months after drilling operations cease at a drilling site and include all components from the Phase III assessment with the addition of evaluation of the benthic community structure.

3.1. Phase I Assessment

The NPDES permit requires a baseline site characterization to be conducted as part of the Phase I assessment, but allows for data collected under other agency requirements or in a voluntary fashion, within the most recent 5-year period at or in the vicinity of the drill site location, to be submitted for consideration of meeting the requirement. The goal of this section is to present and demonstrate that sufficient baseline data exist throughout the northeast Chukchi Sea that can serve as a replacement for Phase I sampling at drilling locations within the Burger study area.

A substantial amount of baseline science and site characterization data exists for the Chukchi Sea OCS as a result of extensive, multidisciplinary research programs (both industry and government) that have been conducted during the past five years. Empirical data from the past five years exist for the Chukchi Sea from two large, comprehensive baseline studies that have been conducted annually for three and five years, respectively.

The Chukchi Sea Offshore Monitoring in Drilling Area: Chemical and Benthos (COMIDA CAB), a Bureau of Ocean Energy Management-funded study, collected chemical and benthic-ecology data for two years in 2009 and 2010. An extension of COMIDA CAB—Hanna Shoal Ecosystem Study—is a 2-year program begun in 2012 that has collected chemical and benthic-ecology data for one year (2012) and is presently conducting a second year of sampling (July/August 2013). The COMIDA CAB sampling stations in the northeastern Chukchi Sea are shown in Figure 4.

The Chukchi Sea Environmental Studies Program (CSESP), a joint industry-funded study began in 2008 and has collected a diverse and multi-disciplinary dataset for the past five years. CSESP studies included environmental chemistry and benthic ecology, as well as physical oceanography, marine mammals and seabirds, and other disciplines. CSESP data were collected at three 30x30 nautical mile blocks (Klondike, Burger and Statoil). Only the Burger study area data (with some contemporaneous stations in the immediate vicinity of the Burger study area) are included here (i.e., Klondike and Statoil study area data are not presented) (Figure 4).

In addition, a discharge monitoring program (DMP) was voluntarily conducted by Shell, in 2012, in which Phase I-equivalent data were collected at 18 stations around the Burger A drill site. The DMP stations represent spatially-intensive sampling points and are shown in Figure 4 (insets). These comprehensive programs (i.e., COMIDA CAB and CSESP) provide a unique combination of government-funded and industry-funded data sets that, in conjunction, provide empirical data specific to the northeastern Chukchi Sea region, for the Burger prospect area, as well as specific drill sites such as the Burger A drill site.

Information generated from these programs during the last five years, representing different geographical parts of the Chukchi Sea, was compiled and synthesized. Data analyses were conducted to determine variability within and among data sets from the same region and to establish that historical data from a larger geographical area may be predictive of current baseline data at site-specific locations.

A summary of the available baseline site characterization data is provided in Appendix A. This summary clearly demonstrates that existing information and data are sufficient to characterize baseline conditions for the components listed in section II.A.f. of the NPDES permit:

1. Initial physical sea-bottom survey;
2. Baseline physical characteristics (physical oceanography);
3. Receiving-water chemistry and characteristics; and
4. Baseline benthic-community structure.

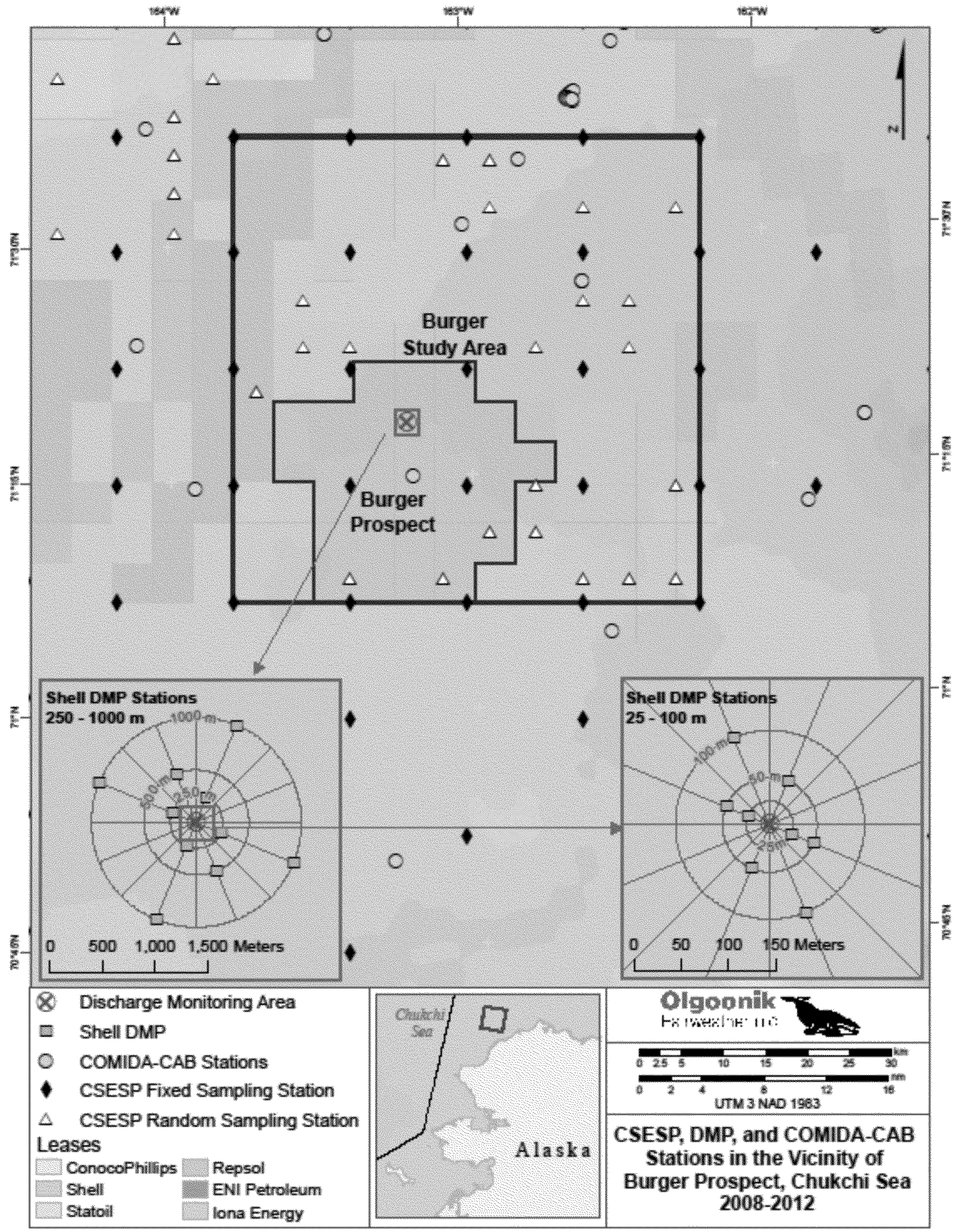

Figure 4: CSESP, DMP and COMIDA CAB stations in the vicinity of Burger prospect, Chukchi Sea, 2008-2012.

Receiving water chemistry for hydrocarbons and metals that have not been measured in the past in the Chukchi Sea will be collected during the Phase II monitoring activities instead of during Phase I. Samples will be collected at specified "reference stations" that will be far-field from the drilling operations. See Section 3.2.4 and Figure 8.

In addition, because water-based drilling fluids and drill cuttings (Discharge 001) will be discharged, the summary provides additional baseline data for the components listed in section II.A.13.j.2 and 3:

1. Sediment characteristics; and
2. Benthic community bioaccumulation monitoring.

Of particular note with respect to the Phase I pre-drill baseline data requirement, is the clarification regarding soft corals in the Chukchi Sea. News releases from 2012 suggest that sensitive species, specifically soft corals, were newly discovered in the Burger study area and are a critical habitat at the drilling location (http://www.greenpeace.org/usa/en/media-center/news-releases/Abundant-corals-discovered-at-Shells-Chukchi-drill site/). The soft coral in question, the Sea Raspberry (*Gersemia fruticosa* and *G. rubiformis*), is well known and widely dispersed throughout the North Pacific, the Bering Sea, Alaska's coastal waters, and the Chukchi Sea. Based on the extensive CSESP sampling from 2008 to 2011, there do not appear to be any habitats or species that can be designated as critical or unique in the Burger study area or specific Burger drill sites. Additional support for this conclusion can be found in the rejection of *Petition to list 44 coral species under the Endangered Species Act (ESA)*, published in February 2013 in the Federal Register (Federal Register, volume 78 number 31).

These existing data meet the Phase I data collection requirements and are submitted for consideration as Phase I baseline site characterization data for this EMP, as per the NPDES permit.

3.2. Phase II Assessment

The primary goal of the Phase II assessment is to characterize, to the extent possible, "physical and chemical concentrations throughout the discharge-affected water column and discharge plume." As per the permit, there are four monitoring requirements required in Phase II:

1. Effluent toxicity characterization;
2. Non-contact cooling-water (Discharge 009) plume observations for potential marine-mammal deflection during periods of discharge;
3. Water-based drilling fluids/drill-cuttings metals and hydrocarbon analysis; and
4. Plume monitoring and observations.

Of these four required components, effluent toxicity characterization and plume monitoring and observations require the most intensive sampling and analysis. Water-based drilling fluids/drill-cuttings analysis will provide empirical data on chemical concentrations present in these drilling components, which will help inform the analysis of samples collected during the plume monitoring component. The results from each of these four required components, taken together, help to evaluate any potential impacts from the activities, during the active exploratory drilling operations. The following sections describe in greater detail the scientific approach for each component. Based on the permit requirements, development of the initial toxicity screen is critical to effluent toxicity characterization because this toxicity screen will dictate whether whole effluent toxicity (WET) testing is triggered for certain discharges. The sampling design and conceptual approach for plume monitoring is also described in the following section.

3.2.1. Effluent Toxicity Characterization

Thirteen different discharge streams are defined in the general permit (AKG-28-8100) for the Chukchi Sea Oil and Gas Exploration (EPA 2013), six of which require toxicity characterization as part of the monitoring process for discharge compliance. The six discharges are deck drainage (002), desalination (005), boiler blow-down (007), fire control (008), non-contact cooling water (009) and bilge (011). Table 5 provides a summary of each of these six discharge types and estimated number of samples that could be tested for each exploratory drilling well if all discharges were operational during drilling of the well.

Table 5: Example scenario of the maximum number of effluents collected and tested.

Discharge #	Discharge Description	# of Outfalls by Discharge type			Number of Initial Toxicity Screening Samples/Well	Operation of the Discharges
		Port	Starboard	Total		
002	Deck drainage	-	-	1[2]	4	Periodic discharge of effluent
005	Desalination	1	1	2	8	Continuous discharge of effluent
007	Boiler blowdown	-	-	1	4	Discharge of effluent is seldom and generates approximately 26.5 L; 61 L are necessary for initial screen and WET.
008	Fire control test	-	-	1	4[1]	Discharges effluent once a month
009	Non-contact cooling water	2	5	7	28[2]	Discharges continuously except for the cement unit. Scheduling for the cement unit might require effluent collection during first event to conduct an initial screen and a WET series for three chronic tests (61 liters).
011	Bilge	-	1	1	4[2]	Discharges effluent intermittently but often enough to schedule Screening and WET
				Totals	**13**	**52**	

[1]Multiple outfall locations are present; however, a sample port above the main header and representative of all downstream water will be used as the single testing location.
[2]Effluent samples are collected after the oil water separator.

Toxicity characterization will consist of an initial toxicity screening process using 100% effluent at four different time periods selected to reflect discharge practices and operational processes. If effluent samples fail the initial toxicity screen (as defined by the toxicity testing threshold limits established for this program), then WET will be conducted using three different species of organisms, including the topsmelt, *Atherinops affinis* (or *M. beryllina,* depending on availability), the mysid shrimp, *Americamysis bahia*, and the purple sea urchin, *Strongyocentrotus purpuratus*. The methods for WET are provided in established EPA procedures outlined in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine Organisms* (EPA-821-R-02-014 Fourth Ed.) and the *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms* (EPA/600/R-95- 136). A split of each sample collected for WET testing will also be analyzed for the chemical and physical parameters identified within the applicable monitoring sections of the general permit. To the degree possible, samples collected for the initial toxicity screening test will be collected at the same time as the samples required for the specific monitoring for each of the six discharges that require toxicity testing, depending on the frequency of the particular discharge. Upon receipt of the toxicity samples at the laboratory, water quality characteristics will be assessed, depending on the particular requirements as laid out in the SOPs. For example, salinity and dissolved oxygen will be measured, among other parameters (discussed below). These data can then be used to assess whether physical/chemical conditions were similar between the initial toxicity screening test and (in the event that a positive initial toxicity screening result is obtained) the WET test. No chemical analysis on the initial toxicity screening samples is required by the permit.

Water quality conditions including temperature, salinity, pH and dissolved oxygen of each discharge type will be measured to confirm optimal testing conditions are created prior to the addition of test organisms. The process for adjusting effluent solutions to testing conditions is described in the laboratory section of this document. This process is required in the EPA-approved methods in order to adjust temperature, salinity or dissolved oxygen conditions to match the optimal conditions for each test organism. A brief description of each discharge type is provided within the context of toxicity testing considerations.

<u>Discharge 002: Deck Drainage</u> -- Deck drainage is the wastewater associated with washing platforms, decks, and equipment and runoff from curbs, gutters, pans and wash areas. The permit requires deck drainage systems separate drains associated with oil and grease wastewater from wastewater not in contact with surfaces containing any oil or grease. The wastewater associated with oil and grease drains are processed through an oil water separator to discharge into receiving waters. The effluent through this treatment system will be monitored using an initial toxicity testing screen. The salinity of this discharge type will be measured and, if necessary, adjusted with brine solutions or artificial sea salts to testing conditions suitable for marine organisms.

<u>Discharge 005: Desalination</u> -- Effluent discharges associated with the creation of fresh water from seawater are likely to be high concentration brines similar to seawater in chemical composition but higher anion and cation ratios. Permit monitoring of desalination discharges

includes initial toxicity screening. The potential high saline conditions of this discharge type may require a reduction of salinity to conditions that are conducive to test organism tolerance ranges.

Discharge 007: Boiler Blowdown -- The materials inside the boiler drums, including water and solids, are periodically discharged to minimize solids buildup in the boiler units. Monitoring of this discharge type includes an initial toxicity screen. It is likely this discharge will be fresh water and contain a large amount of solid materials. If necessary, the fresh water will be adjusted with brine solutions or artificial sea salts to salinity conditions conducive to test organism survival using the guidance provided in the EPA-approved methods.

Discharge 008: Fire Control System Test Water -- This discharge is created from seawater released during fire training exercises and testing and maintenance of fire protection equipment. Monitoring of this discharge type includes an initial toxicity screen.

Discharge 009: Non-contact Cooling Water -- Seawater is used as once-through cooling mechanisms for machinery on the drill rig and consists of the highest volume of discharge authorized under the general permit. For toxicity testing purposes, this discharge water may be at higher temperatures than are considered optimal for test species. The temperature and salinity of the non-contact cooling water will be adjusted to within testing parameters prior to the addition of test organisms.

Discharge 011: Bilge Water -- Bilge water drains into the drilling vessel hull and is processed through the oil water separator. The possibility of aquatic species may exist in this discharge. Effluent samples will be visually inspected using a light table to determine if organisms are present in the effluent. If organisms are observed, the effluent will be passed through a Nytex™ screen large enough to capture the organisms prior to the start of any testing.

3.2.1.1. Rapid Screening Test

The rapid screening toxicity testing process is designed to separate effluent discharge samples requiring further biological testing from those that do not. The main objective of the rapid screening process is to quickly focus on discharges more likely to result in adverse biological effects. Rapidity and sensitivity are two important features of the rapid screening test to demonstrate compliance with water quality goals. There are a number of biological methods that have been developed over the years, with exposure times ranging from less than 1 hour up to 96 hours. The most preferable screening tools for this effluent testing program are those that can be accomplished rapidly (<1hr). This criterion reduces the potential marine screening tools to the Microtox™ test and the echinoderm fertilization test. Table 6 provides general descriptions of potential screening tools, exposure period and method citation.

Table 6: Summary of selected rapid screening tools with exposure times of <24hr.

Test Name	Description of Test	Duration (hours)	Method	Reference
Microtox™ - water assay	Bioluminescent bacteria used to detect toxins. Amount of light emitted during exposure provides indication of toxicity compared to control.	0.25/0.50	(marine or freshwater)	Microbics Corporation 1992
Microtox™ sediment assay		0.25/0.50		
Echinoderm Fertilization-water assay	Echinoderm eggs and sperm are combined and the percent of fertilized eggs is an indication of toxicity compared to control.	0.40	EPA, 2002 - 1008.0 (marine)	Lee et al. 1999
Artotox	Brine shrimp exposed to effluent. Toxicity indicated by percent survival compared to control.	24	EBPI procedure (marine)	
QwikSed (dinoflagellate)-sediment assay	Bioluminescent dinoflagellates used to detect toxins. Reduction or inhibition in light used to indicate toxicity.	24	SeaLife Instruments, Florida (marine)	NFESC TDS-2077-Env, Feb 2000
QwikLite (dinoflagellate) - water assay		24		
Toxi-ChromoPad – sediment assay	Bacterium E. coli grown in solid material. If sample is toxic no color will develop. If sample is toxic a blue color develops.	1.5	EBPI procedure (freshwater)	Lee et al. 1999
Thamnocephalus platyurus- water or sediment	Freshwater crustacean exposed to effluent. Toxicity indicated by percent survival compared to control.	0.5 to 1		
Rototox – water or sediment	Rotifers exposed to effluent. Toxicity indicated by percent survival compared to control.	24		ASTM, 1991 E 1440-91

A comparison of the Microtox™ test and the echinoderm fertilization test was conducted by Environmental Canada (Buday 2001). The relationship between Microtox™ responses and the echinoderm percent fertilization success were not well correlated. The data from this study was graphically compared and is illustrated in Figure 5. Overall conclusions from the review indicate:

Microtox™ responses in water exposures had no measureable responses for any of the samples tested.

Microtox™ responses for the solid-phase test had significant reductions in light that occurred over a broad range from an inhibitory concentration that affects 50% of a test population (IC_{50}) of 526.9 to 13,080 mg/L (~25-fold).

- Solid-phase Microtox™ responses occurred in samples that showed no significant response using the echinoderm test.
- Acceptable echinoderm fertilization occurred over the entire solid-phase Microtox™ response range (526.9 to 13,080 mg/L) as shown by the blue shaded box in Figure 7.

- Conversely, negative responses from the echinoderm fertilization test showed a range of responses for the Microtox™ test with IC_{50} values occurring at <4,000 mg/L but not for all Microtox samples with these same response levels.

There was no negative response for Microtox™ for the water exposure (this result was assumed to invalidate the test as an acceptable candidate for the NPDES permit program).

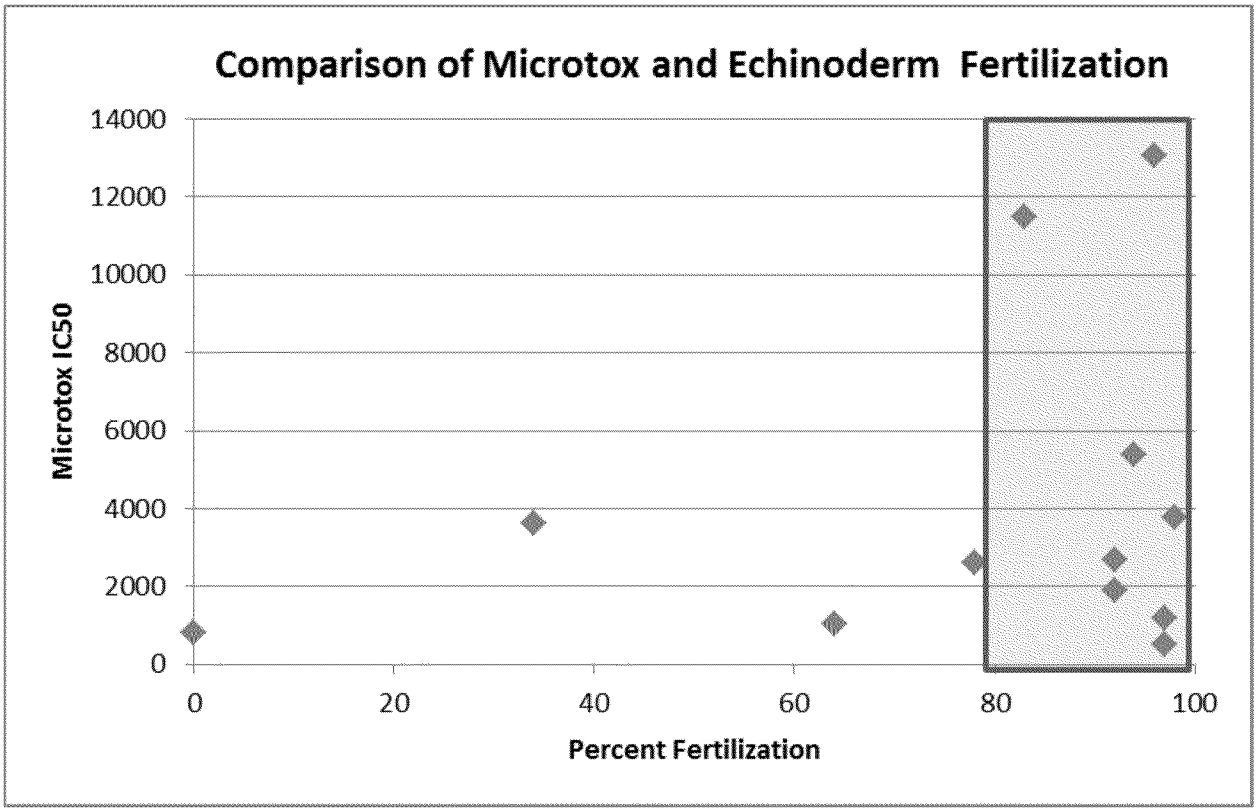

Figure 5: Graphical illustration showing inhibitory concentration that affects 50% of a test population (Microtox™) vs. percent fertilization in echinoderm fertilization test.

In addition to the observations by Buday (2001), a number of studies reported the interference of other environmental parameters, for example elemental sulfur, on the interpretation of the Microtox™ solid phase results (Jacobs et al. 1992, Pardos et al. 1999). Microtox™ responses in treated and untreated effluents were found to show similar results (Dorn et al. 1989). Water samples that contain surfactants at concentrations above a critical toxicity concentration were found to be unacceptable (Sherrard et al. 1996). Literature reviews of the apparent toxicity as measured by Microtox™ exhibit wide ranges. For example, Toussant (1995) found that metal toxicity measured by light output using Microtox (IC_{50}) varied by orders of magnitude (e.g., Zn 0.44 to 476 mg/L; Cu 0.076 to 25 mg/L; Cd 11.6 to 416 mg/L), with a small difference for unionized ammonia ranging from 1.49 to 2 mg/L. Similarly, NewFields (2009) conducted experiments to determine the influence of holding times on the amount of light output and found that the longer a sample was held within acceptable holding times and under acceptable temperatures the higher the incidence of effect on light output and that these results appeared associated with sulfides and ammonia.

Based on the comparison results provided above, the echinoderm fertilization test will be used as the rapid screening tool for this EMP. Unlike Microtox™ test responses, screening with fertilization tests using echinoderm gametes correlates well with other test organism responses. The fertilization test results also show a strong relationship to exceedances of contaminant guidelines for metals, ammonia and polycylic aromatic hydrocarbons (Carr et al. 1996). Test results are ready to be counted within one hour of exposure and yields results that can be interpreted relative to contaminants of interest whereas the Microtox™ test responses may have interferences from extended holding times and fluctuating sulfide and ammonia conditions. Three echinoderm species will be included in the testing guidelines for the NPDES in order to meet windows of reproductively appropriate time frames. The species would include the sand dollar (*Dendraster excentricus*) and the sea urchins (*Strongylocentrotus purpuratus* and *Lytechinus anamesus*). The echinoderm fertilization test is an EPA-approved method (EPA/600/R-95/136).

If the initial toxicity screening test indicates the effluent response is above the biological threshold or if discharge limits are exceeded as specified by 10,000 gallons in a 24-hour period and if chemicals are added to the system, additional WET will be conducted following established EPA methods as described in section 3.2.1 of this document. The screening level toxicity testing results will be reported within the discharge monitoring report (DMR) for the month following the sample collection. The WET testing results will be reported in the DMR that occurs at least two weeks after the completion of the WET testing. The methods for WET testing, which include seven-day Topsmelt larval and survival growth test, seven-day Mysid shrimp survival, growth, and fecundity test, and a 72-hour Purple sea urchin larval survival and development test, are well established. Additionally, EPA standard operating procedures (SOPs) already exist for each test, thus the toxicity thresholds associated with all of the WET testing components are already defined by these existing, validated methodologies. Consequently, WET testing toxicity thresholds are not criteria that Shell is tasked with defining (unlike for the initial toxicity screening). Additional information and detail on WET testing can be found in the project specific quality assurance project plan (QAPP).

3.2.2. Non-contact Cooling Water (Discharge 009) – Marine Mammal Deflections

Shell operates an extensive integrated marine mammal monitoring program in compliance with the Marine Mammal Protection Act (MMPA) during all exploration activities[1]. In accordance

[1]The primary regulation of activities related to marine mammals is the responsibility of the National Marine Fisheries Service (NMFS) and the Fish and Wildlife Service (FWS). Shell's marine mammal monitoring program as outlined herein, or referenced in other locations, is being supplied as part of the requirement for an Environmental Monitoring Program, specifically sections II.13.g.2 and j.4 associated with non-contact cooling water, drilling fluids and drilling muds as outlined in General Permit AKG-28-8100. The submittal of this program is in order to meet the requirements associated with those permit sections, specifically having to do with marine mammal observations during those times of discharge only. Program submittal, nor any reporting provided to EPA as a result of the program, does not act to confer on, or subject the program to, EPA jurisdiction outside of those specific areas, and/or in conflict with any jurisdiction by NMFS or FWS.

with the MMPA, applicants for an Incidental Harassment Authorization (IHA) from the trustee agencies, i.e., National Marine Fisheries Service and U.S. Fish and Wildlife Service, are required to provide a monitoring and mitigation plan. The agencies evaluate these plans through a process of independent peer review and public review prior to authorizing proposed activities. Although the IHA that will cover proposed 2014 drilling operations along with the associated monitoring program is not yet available, it is anticipated that the monitoring program will be effectively the same as the one implemented in 2012. A full description of this program and its results can be found at http://www.nmfs.noaa.gov/pr/pdfs/permits/shell_90dayreport_draft2012.pdf.

In summary, the Shell monitoring and mitigation program includes three integrated components:

1. A vessel-based observer program under which protected species observers (PSOs) on all vessels maintain watch for marine mammals. These PSOs have dual duties to implement any needed avoidance or mitigation measures and to record data on observations, including species, location, activity, orientation toward drilling activities, etc.;
2. An aerial based observer program under which PSOs fly over the area of the drilling activities and observe and record data on marine mammals; and
3. An acoustic program under which industry sounds and marine mammal calls are recorded and can be analyzed for distribution and reaction to drilling related activities.

This integrated program will provide a good understanding of the relative distribution of marine mammals in proximity and relation to the drilling related activities, the relative amount of time individuals may be within an area of potential exposure, and the portion of the population of each species that could potentially be within a range of exposure to drilling related effluents. Correlation of these marine mammal distributional data with records of discharge timing and location will allow assessment of whether discharge specific changes of behavior can be detected. It should be recognized, however, that discharge is one of several factors (sound, proximity of vessels, & non-anthropogenic) that may contribute to, or independently cause, such perceived reactions.

The visual monitoring methods that are employed during vessel based monitoring are similar to those used during seismic and other geophysical marine surveys in 2006-2011 and to those employed during drilling related monitoring in 2012. PSOs are typically stationed on the bridge or from a position on the vessel that allows safety and disturbance zones to be monitored for marine mammals. PSOs are on duty during nearly all daylight periods on vessels and during the night if permits or specific operations require it. Depending on the vessel, watches are conducted with the unaided eye and/or specialized monitoring equipment listed below. For each marine mammal sighting, specific information (species, behavior, heading, reaction, etc.) is recorded. Environmental effort data (ship's position, sea state, ice cover, visibility, airgun status [ramp up, mitigation gun, or full array, etc.]) is also collected. Effort data is recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

PSOs use specialized field equipment to monitor and collect data on marine mammals. PSOs use 7×50 reticle binoculars, Big-eye 10x50 binoculars, Canon 18×60 image stabilized binoculars, Global Positioning System unit, laptop computers, night vision binoculars (NVDs), and digital still cameras. Various factors, including high sea state and poor visibility, can make detection of marine mammals difficult. There is stakeholder interest to evaluate technologies that improve visual detection of marine mammals by PSOs from the vessels. PSOs regularly perform surveys using new technologies in the field, which lead to evaluation of those tools and possible inclusion into future monitoring programs.

A custom-built marine mammal computerized data entry system was introduced in 2012 to streamline data collection and allow PSOs to maintain focus on their observation tasks. The accuracy of the data entry was verified in the field by computerized validity checks as the data were entered and by subsequent manual checking of the database exports. These procedures allow initial summaries of data to be prepared during and shortly after the field season and facilitate the transfer of the data to statistical, graphical or other programs for further processing. In addition to routine PSO duties, observers use Traditional Knowledge and Natural History datasheets and hand-held voice recorders to collect observations that are not captured by the sighting or effort data.

Aerial surveys of marine mammals in the Chukchi and Beaufort seas were conducted in 2006–2008, 2010 and 2012 in support of relatively larger exploration programs. The aerial survey component is designed to provide a systematic assessment of the distribution of marine mammals in areas within and adjacent to exploration operations. Of particular interest is an assessment of bowhead whales during their annual fall migration through the Beaufort Sea and Chukchi Sea, and also beluga whale and Pacific walrus distributions throughout the survey area. The specific objectives are to:

- Collect and report data on the distribution, number, movement and behavior of marine mammals near the exploration operations with special emphasis on migrating bowhead whales;
- Support regulatory reporting requirements related to the estimation of impacts of exploration activities on marine mammals; and
- Investigate potential deflection of bowhead whales during migration by documenting how far from exploration activities a potential deflection may occur, and where whales return to normal migration patterns west of the operations.

High-definition digital still and video cameras are installed aboard survey aircraft for use during flights. Aerial photographic surveys using these cameras and high-definition video are flown by a pilot and co-pilot without PSOs over the Burger Prospect Area in the Chukchi Sea. The incorporation of marine mammal sightings data from digital imagery is part of ongoing efforts to develop and validate technology for use in unmanned aerial systems in future years.

The offshore survey grid is designed to cover a circular area with a radius of 40 km (25 mi) around the exploratory drilling well site as shown in (Figure 6). Transects are spaced 7.2 km (4.5 mi) apart, which allow even coverage of the survey area during a single flight if weather conditions permit completion of a survey. A random starting point is selected for each survey and the evenly-spaced lines are shifted northeast or southwest along the perimeter of the circular survey area based on the start point. The total length of survey lines is approximately 1200 km (746 mi) and the exact length depended on the location of the randomly selected start point.

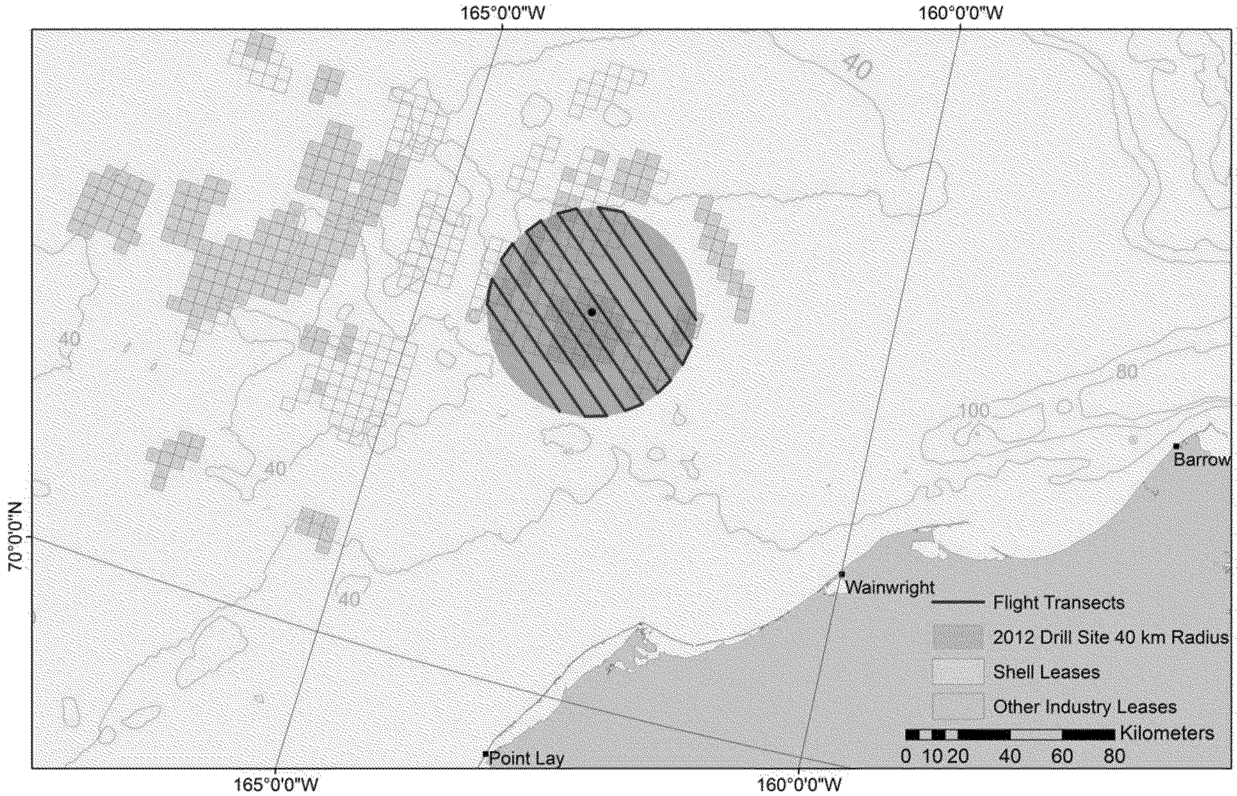

Figure 6: Offshore aerial photographic survey transect locations and general survey pattern for the eastern Chukchi Sea.

The large-scale acoustics program in the Chukchi Sea employs autonomous acoustic recording systems deployed on the seabed for extended periods over large areas of the northeastern Chukchi Sea. An acoustic "net" array, used since 2006, was designed to accomplish two main objectives:

1. Collect information on the occurrence and distribution of marine mammals (including beluga whale, bowhead whale, and walrus) that may be available to subsistence hunters near villages located on the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns; and
2. Measure the ambient soundscape throughout the northeastern Chukchi Sea and to record received levels of sounds from industry and other activities further offshore in the Chukchi Sea.

The recorders operate at a sampling frequency of 16 kilohertz to capture vocalizations from bowhead, beluga, gray, fin, humpback, and killer whales, as well as walruses, seals, and most other marine mammals known to be present in the Chukchi Sea. Over-winter recorders have been deployed in the Chukchi Sea since 2008 at five sites to monitor late fall, winter and spring distributions of marine mammals.

Summer 2012 acoustic data are acquired with 31 Autonomous Multichannel Acoustic Recorders (AMARs) deployed from early August through mid-October 2012 throughout the northeastern

Chukchi Sea. Twenty-two AMARs are deployed in a regional array along four lines extending offshore from Cape Lisburne, Point Lay, Wainwright and Barrow (Figure 7). The drill location is surrounded by seven AMARs.

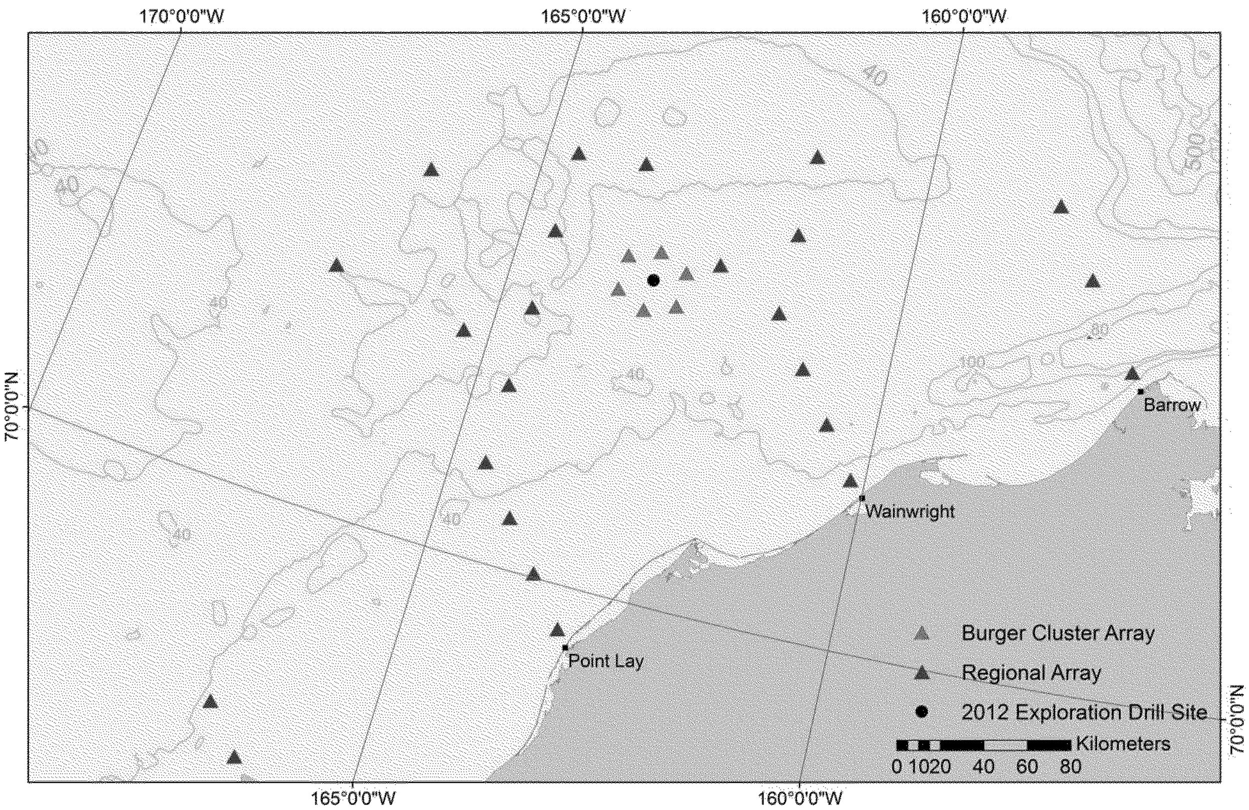

Figure 7: Deployment locations of hydrophones in acoustic arrays in the eastern Chukchi Sea, Alaska 2012.

The acquired acoustic data are analyzed to quantify ambient sound levels, presence of anthropogenic activity (such as vessels and seismic surveys), and the acoustic presence of marine mammals. The program focus remains on bowhead whales, walrus, and beluga whales, but many other detected species have been detected including fin, minke, gray, humpback and killer whales as well as bearded, ringed and ribbon seals.

Analysis of acoustic data from arrays in the Chukchi Sea can address the following questions:

1. Determine when, where and what species of animals are acoustically detected on each recorder;
2. Analyze data as a whole to determine offshore distributions as a function of time;
3. Quantify spatial and temporal variability in the ambient sound energy; and
4. Measure received levels of exploration activity events.

The detection data are used to develop spatial and temporal animal detection distributions as a function of different variables (e.g., time of day, season, environmental conditions, ambient sound energy and vessel sound levels).

3.2.3. Water-Based Drilling-fluids/Drill-cuttings Metals and Hydrocarbon Analysis

Samples of WBMs and drill cuttings will be collected during the drilling operations at three intervals (discussed in Section 3.2.4) which include (1) placement of the largest casing interval (beyond the top hole), (2) penetration of the hydrocarbon zone, and (3) release of bulk muds (if applicable) by an on-rig compliance engineer and then transported to the relevant analytical laboratories to be analyzed for metals and hydrocarbons. Modern WBMs have a limited number of ingredients, and have low toxicity designed to comply with environmental regulations (Neff 2010). Modern WBMs no longer contain metal constituents, such as Sodium Bi-chromate (contains Cr [VI]), that historically were used in drilling activities. The EPA has also established stringent guidelines on Hg and Cd limitations. These guidelines have been effective at limiting concentrations of those metals (and other potentially co-occurring metals) in WBMs. Changes to pipe-dopes and the limited use of additives also have resulted in lower concentrations of metals present in drilling fluids (Neff 2010). Concentrations for most metals present in WBMs typically are within the range of concentrations present in uncontaminated marine sediments (Neff 2010). The one exception is Ba, which due to its role as a weighting agent, is present in higher concentrations.

Although only metals analyses are required in the permit, hydrocarbon analyses will also be conducted on drilling-fluids and drill-cuttings to serve as source samples that will inform data-analysis components in post-drilling phases (phases III and IV). Hydrocarbons are not typically present in WBMs, but may become entrained in muds when penetration of the hydrocarbon zone occurs during exploratory drilling.

3.2.4. Plume Monitoring and Observations

The objective of the plume-monitoring task is to identify the plume(s) resulting from the discharge of drilling muds and cuttings (Discharge 001) and measure "metals, organics, turbidity and total suspended solids throughout the water column" during periods of maximum discharge. Additionally, the objective is to focus characterization efforts to areas of expected deposition of muds and cuttings based on model predictions. Plume monitoring will also serve as a check / verification of modeling of effluent behavior.

Phase II plume monitoring will be conducted on a vessel provided by and under the control of Shell. The vessel will be tasked with other duties but will be made available for plume monitoring for several days during the period when drilling discharges take place. Safety, operational and navigational issues could limit the ability to delineate plumes in the immediate vicinity of the drilling operations. Within these logistical constraints, an effort will be made to locate and sample the plumes originating from the drilling vessel over the various stages of drilling the well.

The following time points during drilling will be targeted to capture the "maximum discharge periods" and periods representing different types of discharge (i.e., potentially different physical and chemical composition of the discharge):

Largest casing interval (beyond top-hole);

Hydrocarbon zone; and

Bulk-mud discharge (if this occurs).

During the three discharge events listed above, seven sampling stations will be targeted for sample collection. An illustration of the Phase II plume sampling stations is provided in Figure 8. Six sampling stations will be located along three transects (two stations per transect) oriented in the direction of the predominant current. The three plume transects will be separated approximately 10-15 degrees from the source. All plume-transect sampling stations will be located within 500 m from the drilling location, with the near-field stations being as close to the discharge as logistically possible. A seventh sampling station will serve as a reference station and be located at least 1,000 m away and perpendicular to the northern end of the downstream plume transect.

The geometry of a discharge plume is directly influenced by the ambient meteorological and physical oceanographic conditions in the vicinity of the well site. Current speeds and turbulent mixing zones at different depths in the water-column can have a substantial effect on the dispersion and deposition rates of particles. Currents within the area of the drill rig are horizontally coherent over distances of 10 to 20 kilometers (T. Weingartner, personal communication); therefore, the location, transport and fate of mud and cuttings plumes will be monitored by using water column velocity data from an acoustic Doppler current profiler (ADCP) and a deployable water column profiler. An ADCP with real-time or near-real time data-transfer capability will be located on, or in the vicinity of, the drill rig to provide information on near real-time currents. Water column velocity data from the ADCP will be used in near real-time to coordinate the deployment of a water column profiler, a Sea-Bird Electronics, Inc., SBE19 (or equivalent) conductivity, temperature, depth (CTD) unit equipped with two turbidity sensors, an optical backscatter sensor (OBS) and a transmissometer. Data from the turbidity sensors, indicating potential discharge of suspended solids, will be used to obtain near real-time multi-dimensional data on water column conditions. Weather data will be acquired in the field to further inform sampling activities.

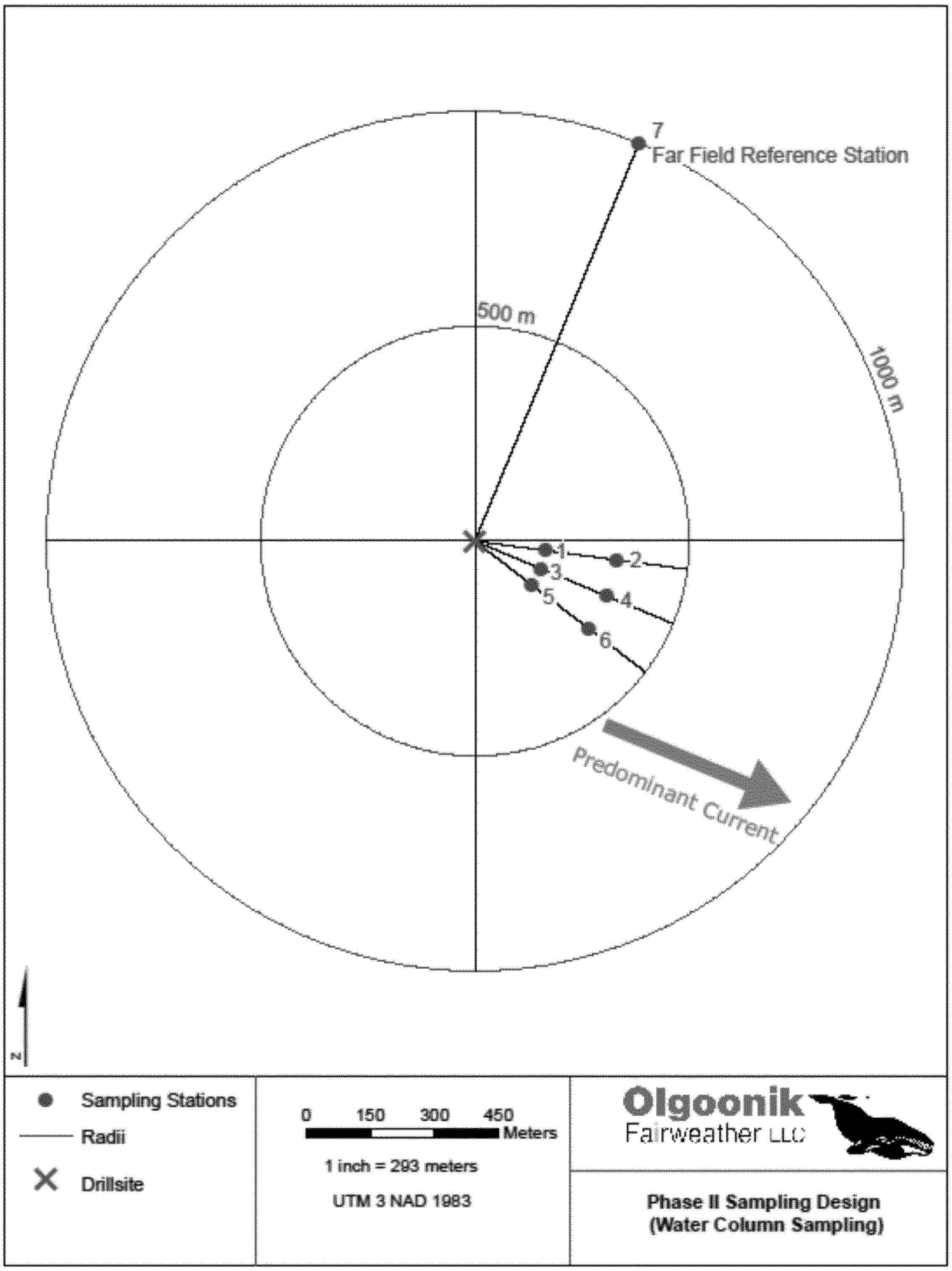

Figure 8: Phase II sampling design (water column sampling).

The CTD unit includes a six-bottle rosette to collect discrete water samples. Samples will be attempted for collection at approximately five different depths in the water column. General target sample depths are approximately 1 m (near-surface), 10 m, 20 m and 30 m below the surface of the water, and 2 m above the bottom of the seafloor. The near-real-time current data from the ADCP and the near real-time water column data from the CTD profiler will be used in an adaptive manner to optimize the location and depth for discrete water sample collection to capture the densest portion of the plume, when possible. Water samples will be analyzed for the following parameters: metals, TSS and organics (volatile organic compounds [VOC], total aromatic hydrocarbons [TAH] including xylenes, total petroleum hydrocarbons [TPH], polycyclic aromatic hydrocarbons [PAH], and saturated hydrocarbons [SHC]). Specific analytes and analytical methods are included in the project-specific QAPP. Turbidity measurements in the water-column will be collected with an OBS and a transmissometer with the CTD attached to the water-sampling rosette. The sensors will be calibrated using in-situ data.

A summary of the Phase II sampling effort is provided in Table 7. The data collected during the Phase II monitoring will be used to assess the location of the plume(s), to refine model inputs, and to help inform the Phase III and IV monitoring efforts. Data from Phase II efforts will also be compared to the chemical analysis results from source samples of the muds and cuttings.

Table 7: Summary of Phase II (sampling water depth may vary depending on in-field measurements of turbidity during plume monitoring, weather conditions, or operational parameters). Total number of samples over all monitoring intervals is 105 (35x3).

Sampling Water Depth	Transect Type	Number of Samples		
		Well Timing – Casing	Well Timing – Hydrocarbon Zone	Well Timing – Bulk Muds[1]
1 m below surface	Plume	6	6	6
	Reference	1	1	1
10 m below surface	Plume	6	6	6
	Reference	1	1	1
20 m below surface	Plume	6	6	6
	Reference	1	1	1
30 m below surface	Plume	6	6	6
	Reference	1	1	1
2 m above bottom	Plume	6	6	6
	Reference	1	1	1
Subtotal		**35**	**35**	**35**

[1]if this event occurs

3.2.4.1. Acoustic Doppler Current Profiler

The ADCP will be positioned no more than 2000 m from the drill site. The data on current speed and direction will be relayed in near real-time fashion to the vessel so that the field team can use it to maximize the effectiveness of the Phase II plume-sampling component. The near real-time current data will provide an estimate of the trajectory of the plume in the field, as shown in Figure 8. Discrete water samples will then be collected from the sampling stations.

3.3. Phase III Assessment

Phase III incorporates post-drill sampling conducted immediately after drilling. In the event unforeseen circumstances prevent environmental sampling of data immediately after drilling, the EPA will be notified immediately to determine the appropriate course of action.

In the event the well is not advanced to the PTD, a partial well may be drilled. For the purposes of sampling relative to the EMP, "end of well means, for purposes of sampling drilling fluids and drill cuttings, at the location where the drill bit is at least 80% of the final well footage (i.e., final well bottom location)" (EPA 2013, Section VII. Definitions, p. 74). Phase III monitoring will not be initiated until after the well is drilled past 80% PTD.

A four-transect design (N, E, S and W) oriented approximately 22.5 degrees to the east of north to allow for sampling along the mean current direction, in conjunction with four different radii at 100 m, 250 m, 500 m, and 1000 m from the drill site location, will be used (Figure 9). A review of the literature on environmental monitoring of exploratory drilling using WBMs indicates the majority of impacts, including chemical, physical and biological, from wells drilled in waters shallower than 200 m occur within 500 m from the drill site (Ellis and Schneider 1997, The Research Council of Norway 2012, Trefry et al. 2013). Hence, 13 of the 17 (76%) near-field sampling stations are located within the literature-defined "impact" zone. This approach results in a total of 17 near-field stations for this program, 16 of which result from each intersection of each of the four transects with each of the four different radii. The additional sampling station occurs in the vicinity of the actual drill site location. Note the overlap of the plume-monitoring transect (Figure 8) for Phase II with that of the 112.5 degree transect for the Phase III and IV sampling design. These transect orientations may be modified in the field, depending on observations made during the field effort (e.g., if the Phase II ADCP data indicate a different trajectory for the predominant downstream current direction during drilling and/or sediment profile imaging [SPI] and grab samples collected post-drilling indicate the deposition [or lack thereof] of muds and cuttings). An additional five stations, the locations of which will be determined iteratively in the field, will be sampled following drilling to attempt to further delineate the spatial and vertical extent of the discharge deposition. The specific locations of these additional stations will be determined based on evidence of muds and cuttings presence in the field from SPI data and/or sediment grab/core samples. At least one of these additional five stations will be attempted at 50 m or closer to the drill site. Sampling closer than 100 m from the drill site is challenging because the research vessel itself is likely to be more than 60 m long. Sampling biota in this small of an area is particularly challenging because the stations are no longer "distinct" (e.g., 2-4 minute clam rake tows are not representative of a single station at 25-50 m from the drill site), which poses challenges from a statistical analysis standpoint. The sampling design for Phase III (and IV) builds on the design for Phase II because water column impacts during drilling are transient and predictable based on real-time water currents. However, post-drill sampling is (and should be) reliant on time-integrated variables such as water currents that change over time, sediment chemical concentrations, and sediment re-suspension and re-deposition.

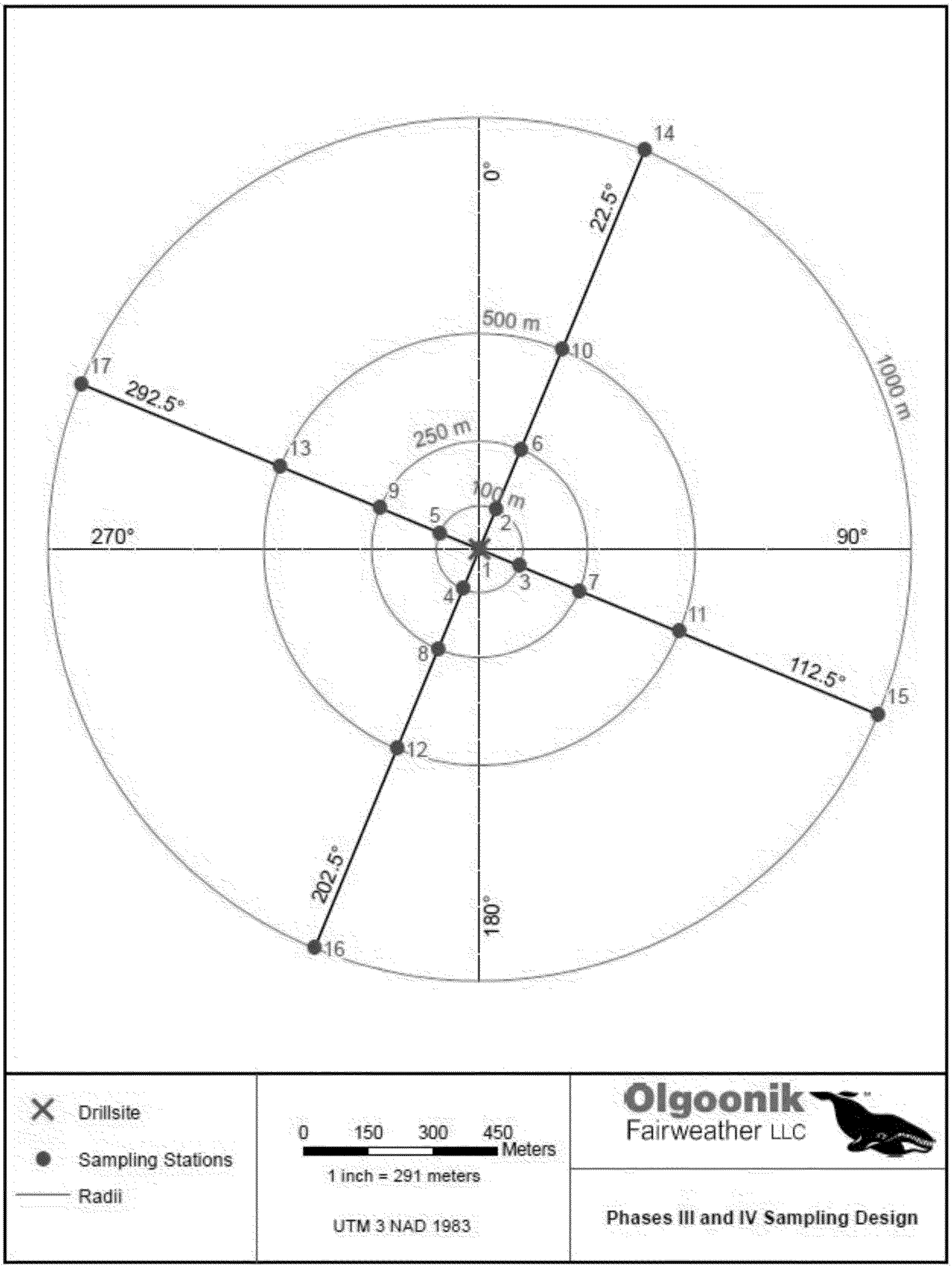

Figure 9: Phases III and IV sampling design (seafloor sampling).

The transect/radii sampling design proposed for Phase III monitoring has been used extensively in the Atlantic Ocean (e.g., Georges Bank region [Neff et al. 1989]), the North Sea (e.g., Norwegian oil exploration and production at Ecofisk, Eldfisk, and other Norwegian oil fields [Gray et al. 1990, Olsgard and Gray 1995, Gray et al. 1999, Iversen et al. 2011, The Research Council of Norway 2012), and in the Gulf of Mexico (e.g., Gettleson et al. 1981). Ellis and Schneider (1996) building off the work done by others (e.g., Gray, Hurlbert, and Underwood) demonstrated that a gradient sampling design is more powerful than a randomized control/impact sampling design (i.e., analyzing randomly placed "impacted" areas vs. "control" areas). The gradient approach allows for an improved distinction between natural variability and putative anthropogenic effects. Additionally, over the course of nearly two decades, the State Pollution Board of Norway standardized the sampling design that has been and is currently implemented at all environmental monitoring locations for oil and gas activities in that country (Olsgard et al. 1995, Gray et al. 1999, Iversen et al. 2011, The Research Council of Norway 2012). This standardized environmental monitoring design, which is used for both oil and gas exploratory drilling activities and production operations, is a four by four transect/radii design in which the sampling stations are placed at geometrically increasing distances from the center (i.e., drill site) and one axis is located along the "dominant residual current direction" (Olsgard et al. 1995). Although the OOC Model predicts deposition from discharged muds and cuttings in the predominant current direction and within a bound of approximately 250-m from the drill site, it is unwise to rely solely on model outcomes to design the post-drilling sampling. The OOC Model does not incorporate all discrete parameters over time that can influence discharge deposition. For example, the water currents in the Chukchi Sea can be variable and may frequently change direction (Weingartner et al. 2005, Weingartner et al. 2011). Similarly, due to the relatively shallow water depths in the Chukchi Sea, currents may be wind-driven during storm events, which can also result in currents that are different from the statistical averages. Changes in current directions and velocities may result in deposition(s) that are not homogeneous along the anticipated statistical current direction. Unlike during drilling monitoring, which is reliant on real-time water current directions and velocities, the post-drilling monitoring, (particularly the Phase IV monitoring because of the duration of time between the Phase III and Phase IV monitoring), is dependent on factors such as sediment re-suspension and re-deposition, which can result in modified spatial and temporal deposition footprints. For these reasons, the transect/radii transect sampling design with the additional five targeted stations targeted along the predominant current direction is the best approach to environmental monitoring for exploratory drilling.

Samples collected during Phase III will consist of sediment for chemical and physical analyses, clam tissues for chemical analysis, and digital SPI photographs of cross-sections of the sediment-water interface (Table 8). Target locations for clam sampling will be stations 3, 7, 11 and 15 (i.e., along the average predominant current transect). Actual locations will be determined in the field based on the availability of clams.

Table 8: Summary of Near-Field[1] Phase III and Phase IV samples slated for collection.

Discipline	Number of Stations	Number of Samples
SPI	17	17[2]
Benthic ecology (Phase IV only)	17	85 (5 reps)
Chemistry – sediments	17	17
Chemistry – biota (clams)	4	4

1 Far-field samples will be collected at two to four stations contemporaneous with the near-field stations. Far-field stations will be consistent with a subset of stations from the CSESP. An additional five stations will be determined from data in the field during drilling and in-field observations (e.g., SPI and/or sediment grabs/cores) for further delineation of the discharge deposition(s) post-drilling. At least one of these stations will be attempted at 50 m or closer to the drill site.
2 Multiple photographs will be taken at each station (plan-view and cross-sectional) to ensure at least one high-quality photograph per station.

3.3.1. Physical Sea-bottom Survey

Plan-view digital photographs of the seabed and/or profile digital photographs of the sediment–water interface will be obtained with SPI technology and/or other similar technology such as a camera-sled or remotely-operated vehicle (ROV). Images will be assessed to characterize seabed conditions immediately after (as soon as practical) cessation of the drilling operations. Data from the plan-view and/or profile photographs will be used to characterize the spatial extent and depth/thickness of solids deposition as a result of water-based drilling fluids and drill cuttings discharges (Discharge 001) and muds, cuttings, and cement and muds and cuttings at the seabed (Discharges 012 and 013, respectively). In the event that SPI is used, it can facilitate in situ observations at and between benthic-sampling stations, thereby increasing the weight-of-evidence approach's ability to characterize horizontal and vertical impacts on the benthic habitat. SPI technology involves the use of submersible digital camera equipment to penetrate and acquire vertical-profile photographs of the upper 10-20 cm of the seabed sediment that can be analyzed for a variety of physical, chemical and biological parameters. A secondary camera is used to obtain plan-view images of the seabed surface.

During the post-drill survey, photographic data will be collected at each of the 17 near-field stations depicted in Figure 9. Sampling will occur at 16 stations along 4 designated transects at predetermined angles and at four concentric radii from the drill site (100 m, 250 m, 500 m and 1000 m), plus at one station in the vicinity of the drill site location.

As previously discussed, five additional stations (e.g., in the downstream direction within the 500 m radii) will also be sampled in the drill site area during Phase III to enable more precise delineation of any sediment accumulation resulting from drilling discharges, based on near real-time interpretation of the images obtained in the field. These data may be used to augment conclusions from the Phase II monitoring. Spatial variations in the SPI parameters measured after drilling and at contemporaneous reference stations will be evaluated. Mapped data will be contoured and stations will be ranked with parameters such as organic sediment index (OSI).

Areas of the highest and lowest habitat quality or other measurable effects will be depicted graphically.

3.3.2. Sediment Characteristics and Discharge Effects

Sampling will be conducted at each of the 17 near-field stations and the five additional stations to evaluate chemical and physical sediment characteristics following drilling activities and to determine the lateral extent of deposition of drilling muds and cuttings. The thickness of the depositions on the seafloor will also be measured via photographic evidence (Section 3.3.1) in conjunction with sediment sampling (e.g., van Veen grabs). Based on the knowledge of chemicals associated with drilling operations (and on EPA requirements), the focus for this study will include analysis of organics, metals, total organic carbon (TOC), and grain-size distributions.

Organic contaminants for analysis will include PAH, TPH, SHC and petroleum biomarkers. These compounds are consistent with the list of organic chemicals analyzed in the 2008 characterization study in the Chukchi Sea and the 2012 baseline monitoring at the Burger A drill site allowing for consistent comparison with the baseline sediment-chemistry data. Barite is used as a weighting agent in drilling muds and can typically be found in concentrations that are elevated above background in the immediate vicinity of drilling operations and in the areas where the discharge plume is deposited. High-purity barite weighting materials will be used containing only trace concentrations of metals (Neff 2005). Metals and hydrocarbons for analysis in sediments are listed in the project-specific QAPP. Sediment chemical concentrations from Phase III will be compared with existing baseline data and with the source samples—muds and cuttings collected during Phase II monitoring—for a comprehensive post-activity evaluation and analysis.

3.3.3. Benthic Community Bioaccumulation Monitoring

Targeted biota for collection for chemical analysis includes clam tissues (benthic) and amphipods (epibenthic). Both clams and amphipods are important infauna and epibenthic invertebrate species, respectively, in the Arctic food web (Dunton et al. 2012a). In the Arctic (as well as elsewhere), clams are typically representative of lower level (2-2.4) trophic levels (e.g., Dunton et al. 2012a) and are good indicator species for measuring bioaccumulation from benthic exposure because they are filter feeders, benthic omnivores, and/or deposit/subsurface feeders (depending on the particular species), relatively sessile, and do not typically possess the enzyme systems for metabolizing hydrocarbons (Neff 2010, Dunton et al 2012). Clams constitute an important food source for walrus and some seal species that feed in the benthic environment. Amphipods, depending on the particular species, are primary food for grey whales, typically fall in a higher trophic level than benthic clams (e.g., trophic level 2.8-3.9 in the Alaskan Beaufort Sea), and inhabit the epibenthos (Dunton et al. 2012a). Methods of collection for both types of targeted biota will be similar to those used previously in CSESP (Neff et al. 2010), other Arctic programs (Neff and Durell 2011) and COMIDA (Dunton et al. 2012b).

3.3.3.1. Benthic Clams

An attempt will be made to collect clam samples at four of the stations where sediment samples and samples for benthic community-structure evaluations (in Phase IV) are also sampled, initially targeting stations along the transect that represents the average current direction (e.g., stations 3,7,11, and 15 in Figure 9). Due to natural patchiness and variability in abundance of these larger infaunal organisms, it is particularly challenging to collect adequate sample biomass at a pre-determined station. Clam collection will be attempted using a combination of double van-Veen grab and towed clam rake. The sediment remaining following sediment sample collection for sediment chemical analysis using the double van-Veen grab sampler, will be sieved through a coarse sieve (e.g., 1") to sample for clams. Previous work done in the CSESP program to collect clams for chemical analysis have demonstrated better success using a towed clam rake than using the van-Veen grab. The clam rake consists of a stainless steel pronged rake with a Vexar-net attached to "catch" material as the rake is dragged through the sediment. The Vexar-net has approximately ¼" holes that allow for water to pass through while the solid materials (including biological materials) are retained in the net. The clam rake is deployed from the vessel using an A-frame (or similar) and a winch/block system. When the rake reaches the sediment-water interface, it is towed at approximately 2 knots for a few minutes to cover a lineal distance of ~30 m/on bottom time minute. Samples will be targeted at the specific defined stations, rather than towed along a transect. The rake is towed around a station in a circle or semi-circle (to the degree possible, depending on weather/sea state). This can present challenges for the stations in close proximity to the drill site. Typically the duration of the tow is determined in the field depending on the "haul" that is obtained following the first few tows. At the cessation of the tow, the rake is returned to the vessel via the winch/block system and the haul is collected into clean, plastic tubs for sorting. A typical area towed represents approximately 150-200 m^2.

Ideally, samples will represent composited single clam species (not individuals; clams are typically not large enough in size in the Chukchi Sea to provide enough tissue mass for chemical analysis. When tissue mass is limited, multiple species of clams may be composited from a single station to ensure adequate tissue mass for chemical analysis. Review of the nitrogen isotope ratios for the clams to be potentially collected indicate they are all very similar in trophic position (Dunton et al. 2012a). Sampling station locations may change based on the availability of the clams. Higher level organisms such as crabs, polychaete worms and fish will not be attempted for collection for tissue analysis because these organisms metabolize polycyclic aromatic hydrocarbons and other organic contaminants (e.g., Driscoll and McElroy 1996, Forbes et al. 2001). A total of four clam stations will be sampled for collection in the Phase III monitoring.

3.3.3.2. Epibenthic Amphipods

An attempt will be made to collect amphipod samples at four of the stations where clams are also sampled, initially targeting the same stations along the transect that represents the average current direction (e.g., stations 3,7,11 and 15 in Figure 9). Due to natural patchiness and variability in abundance of organisms, it is particularly challenging to collect adequate sample sizes at pre-determined stations for some of the potential species.

Amphipods will be sampled using baited modified minnow-traps deployed at the target stations. Traps are lined with Nytex mesh (to minimize loss of any amphipods in the traps upon retrieval), baited, attached to a long-line and anchor weight and deployed off the vessel. Traps are soaked for 8-12 hours (approximate time which is dependent on vessel logistics and weather/sea state) and retrieved using a grappling hook. Upon retrieval, the amphipods are transferred with care from the traps to a clean, fine mesh sieve, and thoroughly rinsed. In the event that preliminary data (e.g., Nitrogen-15 (^{15}N) values) indicate the amphipod species sampled in this manner are more representative of organisms higher on the trophic level (i.e., which represents scavenger feeding on dead/decaying fish and whales), the method of amphipod trapping may be modified to include a benthic net trawl (or similar) which would target the smaller, benthic omnivore amphipods, rather than the benthic predator amphipods (Dunton et al. 2012).

Ideally, samples will represent composited single amphipod species, of hundreds of individuals. However, when tissue mass is limited, multiple species of amphipods may be composited from a single station to ensure adequate tissue mass for chemical analysis. Locations may change based on the availability of the amphipods in the event that they are not present in adequate numbers. A total of four amphipod stations are proposed for collection in the Phase III monitoring.

3.4. Phase IV Assessment

The sampling that occurs for the Phase IV, no later than 15 months after drilling operations cease at a drilling site, monitoring must follow the same sampling design as for the Phase III sampling, as per the NPDES permit. Refer to sections above for discussion of the physical sea-bottom survey, sediment characteristics and discharge effects, and benthic-community bioaccumulation monitoring. The same types of samples will be collected in Phase IV as in Phase III, at approximately the same locations, and collection of the same numbers of samples will be attempted. Benthic community structure sampling and analysis will be added for the Phase IV assessment to measure and assess any potential long-term impacts to the benthic community as a result of exploratory drilling operations.

3.4.1. Physical Sea Bottom Survey

Plan-view digital photographs of the seabed and/or profile digital photographs of the sediment–water interface and will be obtained with SPI technology and/or other similar technology such as a camera-sled or ROV. See discussion in Section 3.3.1 for details.

3.4.2. Benthic Community Structure

Benthic invertebrate communities are a key component in the Chukchi Sea food web, providing benthic–pelagic coupling of organic carbon from sediments to pelagic populations, including many species of marine fishes, birds and mammals. Benthic-feeding marine mammals in the Chukchi Sea include bearded and ringed seals, walruses, gray whales, and occasionally Bowheads (Bluhm and Gradinger 2008). Walruses migrate through the Chukchi Sea and probably are the main mammalian predator on benthic bivalves and other large benthic invertebrates in the study area (Fay 1982). Nutrients and contaminants bioaccumulated in benthic invertebrates may pass through the Chukchi Sea food web to marine animals valued by subsistence fishers and hunters.

Benthic invertebrates living in sediments (infauna) are excellent indicators of disturbance in the benthos (Boesch and Rosenberg 1981). These sediment-dwelling organisms are either sessile or unable to move large distances (relative to the scale of disturbance events). Thus, they must adjust to environmental change or disappear from the altered environment. Assessments of disturbance events usually focus on change in the community composition of benthic animals due to the differential responses of the animals to stress at individual and community levels. Therefore, benthic invertebrates will be collected for community-composition analysis by methods similar to those used in the CSESP (Blanchard et al. 2010, 2011, In submission a). Photographic documentation will provide a complementary data set to the evaluation of benthic community structure by providing the opportunity to document sediment habitat characteristics and changes in benthic faunal distributions within sediments via digital photography.

3.4.3. Sediment Characteristics and Discharge Effects

Sediment chemical concentrations from Phase IV will be compared with existing baseline data and with the source samples—muds and cuttings collected during Phase II monitoring—for a comprehensive post-activity evaluation and analysis. See discussion in Section 3.3.2 for details.

3.4.4. Benthic Community Bioaccumulation Monitoring

A total of four clam stations and four amphipod stations are proposed for collection in the Phase IV monitoring. See discussion in Section 3.3.3 for details.

4. TECHNICAL METHODS

The following includes a summary of the field and laboratory analytical approaches. Brief summaries are presented here. Detailed information can be found in the project-specific QAPP.

4.1. Field Methods

A project-specific QAPP is prepared in conjunction with this EMP document and will be used for the execution of the field program. The QAPP describes the field protocols in detail, including SOPs.

4.1.1. Collection of Phase II Samples

4.1.1.1. Effluent Samples for Toxicity Analysis

Under the Phase II Assessment, effluent samples for toxicity analysis will be collected by grabs of the effluent from six discharges. The effluent samples will be collected from the discharge stream after the last treatment on the drilling rig and before the discharge stream enters the receiving waters. A split of each sample will be collected for chemical and physical analysis as described in the project specific QAPP. Effluent samples for toxicity analysis will be collected in pre-cleaned carboys and kept on ice in coolers under proper chain-of-custody (CoC) procedures, as outlined in the project-specific QAPP associated with this program.

4.1.1.2. Discrete Water Samples (Plume Monitoring)

Plume tracking will be conducted by integrating water column velocity data to predict the plume direction and inform the location of water column profile and discrete sample collection. Water column profiles will be accomplished with a CTD system augmented with OBS and transmissometer sensors for turbidity measurements. The CTD is connected to a rosette water sampler with collects discrete water samples at various depths. Sensor data and discrete water samples will be collected to provide information on water column chemical and physical characteristics within and outside of the plume(s). Discrete water samples will be collected for water-chemistry and water-quality measurements.

Field SOPs and accuracy and precision for the instruments are included in the project-specific QAPP.

4.1.1.3. Muds and Cuttings

Two samples of used WBM and two samples of drill cuttings will be collected during each of the same three periods of the drilling in Phase II that will include plume-monitoring. Sample-collection methods, containers, storage requirements, and holding-time requirements are detailed in the project-specific QAPP. Drilling-mud compositions and monitoring records will be obtained from the drill-rig supervisor as available.

4.1.2. Collection of Phase III and Phase IV Samples

4.1.2.1. Physical Sea-bottom Survey

SPI and/or similar photography techniques will be used to monitor the physical and benthic-infaunal characteristics in surface sediments (upper 10–20 cm) in the study area after exploratory drilling is completed (Phase III). If real-time assessment of the images in the field suggests a steep gradient between sites with noticeable deposition and sites with no visual signs of disturbance, the system will be deployed between the predetermined locations based on best professional judgment in the field, in conjunction with logistical constraints and/or weather conditions. Field SOPs are included in the project-specific QAPP.

4.1.2.2. Benthic Ecology Sampling

Benthic invertebrate sampling will not occur during Phase III monitoring, but will occur, as per permit requirements, in Phase IV no later than 15 months after drilling operations cease at a drilling site. Benthic invertebrates will be sampled with techniques and methods consistent with those used for the CSESP for community ecology (Blanchard et al. 2011). Infauna will be collected with a double van Veen grab and then sieved through a 1.0-mm-mesh screen (the standard for investigations in Alaska with fine sediments). Five replicate samples will be collected at each sampling location. Field SOPs are included in the project-specific QAPP.

4.1.2.3. Sediment Sampling

Sediments will be sampled at 17 near field stations with a double van Veen grab sampler. Sediment samples will be collected from the top 2 cm (i.e., the surficial layer) of sediments. Depending on sediment observations from van Veen grab collections, gravity-core samples also may be collected in the field to obtain truly undisturbed cross-sectional samples of the sediment layer and to provide information on "the areal extent and depth/thickness of solids deposition caused by Discharges 001 and 013." If collected, the sediment-core samples would be obtained most likely in the immediate vicinity of the drilling location and at the stations located within the downstream 100-m and 250-m concentric radii from the drill site. If evidence exists in the field beyond the 100-m radii of muds or cuttings thicker than expected based on model results, additional core samples may be taken. This decision concerning additional coring will be made at the discretion of the field team leads.

During collection of sediment samples, extreme care will be taken to avoid contact with hydrocarbon sources and any possible metals contamination. For example, samples will be collected from the internal portion of the sample only (i.e., not from the sides that are touching the actual van Veen grab). Field SOPs are included in the project-specific QAPP.

4.1.2.4. Biological Sampling for Bioaccumulation Monitoring

Bivalve (clam) samples will be collected by using a combination of a clam rake and double van Veen grab sampler at the same station. Previous efforts at collecting bivalves and other benthic organisms in the Chukchi Sea during the 2008 CSESP and the 2012 DMP indicated that clams are not obtained with the double van Veen grab sampler in numbers adequate for tissue volumes required for chemical analyses. However, use of a clam rake towed for a few minutes typically allows for collection of numerous bivalves. Because sample size is important for chemical analysis (i.e., having enough sample volume for all analyses), the use of the clam rake is warranted for bivalve collection. Target bivalve species include *Astarte* spp. and *Macoma* spp. If clams are not available at the time of sampling, collection of alternative organisms such as amphipods may be attempted. The species of the bivalves will be determined as best as possible in the field. However, species will be confirmed by taxonomic identification in the Benthic Ecology Task. Field SOPs are included in the project-specific QAPP.

4.2. Laboratory Methods

A project-specific QAPP is prepared in conjunction with this EMP document and will be used for the execution of all laboratory-based analyses. The QAPP describes the analytical requirements in detail, including detailed method descriptions or references (e.g., sample preparation protocols, instrument calibration and sample analysis specifications) and data-quality objectives (e.g., method detection limits, quality assurance [QA]/quality control [QC] program and criteria, data reporting and qualifying scheme). Additionally, the laboratory requirements for the benthic community structure analysis and digital photographic analysis are presented in the QAPP.

4.2.1. Samples for Metals Analysis

Samples of drill cuttings, mud samples, water, sediments, and tissues will be analyzed for a suite of metals. The analyses will be conducted following protocols that have been developed specifically for reliable trace-level analysis of the target metals in complex marine environmental samples. The analytical protocols have been used extensively for baseline characterization and monitoring the potential impact of off-shore oil and gas activities in Alaska, including in the CSESP, COMIDA CAB, Arctic Nearshore Impact Monitoring In Development Area (ANIMIDA) and Continuing Arctic Nearshore Impact Monitoring In Development Area (cANIMIDA) programs.

4.2.1.1. Water

Dissolved water samples collected during drilling activities (Phase II) will be analyzed for a suite of metals. Particulate water samples collected during the plume-monitoring component in Phase II will also be analyzed. Details can be found in the project-specific QAPP.

4.2.1.2. Sediments

Drilling muds and cuttings samples collected during Phase II and sediment samples collected during phases III and IV will be analyzed for a suite of metals. Details can be found in the project-specific QAPP.

4.2.1.3. Tissue

Tissue samples collected during Phases III and IV will be analyzed for a suite metals. Details can be found in the project-specific QAPP.

4.2.2. Samples for Hydrocarbon Analysis

Samples of water, drilling mud, cuttings, sediment and tissues will be analyzed for a suite of VOCs (only in water and muds and cuttings), PAH, petroleum biomarkers (not analyzed in water), TPH and SHC compounds. The analyses will be conducted following protocols that have been developed specifically for reliable trace-level analysis of the target parameters in complex marine environmental samples. The analytical protocols have been used extensively for baseline characterization and monitoring the potential impact of offshore oil and gas activities in Alaska, including in the CSESP, ANIMIDA, and cANIMIDA programs.

4.2.2.1. Water

Water samples collected during Phase II will be extracted for VOC (TAH), PAH, SHC and TPH, following laboratory SOPs (see project-specific QAPP). Detailed analytical methods and additional information are described in the QAPP.

4.2.2.2. Sediment

Samples of drilling muds and cuttings collected during Phase II and sediment samples collected during Phases III and IV will be extracted for VOCs (muds and cuttings only), PAH, SHC, TPH and petroleum biomarkers, following laboratory SOPs. Sediment grain size and TOC content of the sediments will also be determined. Detailed analytical methods and additional relevant information are described in the project-specific QAPP.

4.2.2.3. Tissue

Samples of biological tissues collected during Phases III and IV will be extracted for PAH, SHC and TPH, and petroleum biomarkers following laboratory SOPs. Detailed analytical methods and additional relevant information are described in the project-specific QAPP.

4.2.3. Samples for Benthic Community Structure and Taxonomic Analysis

Taxonomic analysis will be conducted on infaunal invertebrates to determine community composition. Resulting metrics include taxonomic identification, abundance (individuals m^{-2}), and biomass (g m^{-2}). SPI and/or similar technologies (e.g., ROV) and plan-view photography will be analyzed according to methods described by Blake et al. (2009), with results incorporated into the community analyses. QC methods for benthic taxonomic analysis will follow guidelines outlined in Blanchard et al. (2010) adapted from the EPA Environmental Monitoring and Assessment Program (www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/field/labman.html). Detailed methods and additional relevant information are described in the project-specific QAPP.

4.2.4. Analysis of Photographic Images

The range of parameters assessed in the photographic images is presented in the project-specific QAPP. The summarized parameters include: sediment grain size, prism penetration, surface relief, apparent color redox potential discontinuity layer, surface features, subsurface features, successional stage and OSI. Detailed methods and additional relevant information are described in the project-specific QAPP.

4.2.5. Samples for Toxicity Testing

Test methods for conducting the WET testing on specified waste streams are summarized below. Table 9 includes the suite of WET tests required to be performed on the effluents. Also summarized in Table 11 is the method for conducting the suspended particulate phase (SPP) acute toxicity test on drilling fluids (muds) used at the site(s). Additional details can be found in the project-specific QAPP. Upon receipt of the toxicity samples at the laboratory, water quality characteristics will be assessed, depending on the particular requirements as laid out in the SOPs. For example, salinity and dissolved oxygen will be measured. These data can then be used to assess whether physical/chemical conditions were similar between the initial toxicity screening test and (in the event that a positive initial toxicity screening result is obtained) the WET test. No chemical analysis on the initial toxicity screening samples is required by the permit.

Table 9: Summary of WET species.

Marine Chronic Toxicity Tests	Species	Method
Larval Fish Seven-Day Larval Survival and Growth Test	Topsmelt (*Atherinops affinis*) or Inland Silverside[1] (*Menidia beryllina*)	EPA/600/R-95/136 EPA-821-R-02-014
Mysid Shrimp Seven-Day Larval Survival, Growth, and Fecundity Test	*Americamysis bahia* (Formerly *Mysidopsis bahia*)	EPA-821-R-02-014
Echinoderm Larval Survival and Development Test	Purple Sea Urchin (*Strongylocentrotus purpuratus*) or Sand Dollar (*Dendraster excentricus*)	EPA/600/R-95/136

[1]Menidia beryllina may be used as a substitute for topsmelt

Drilling Fluid SPP Toxicity Tests	Species	Method
Larval Fish 96-Hour Survival	*Americamysis bahia* (Formerly *Mysidopsis bahia*)	40 Code of Federal Regulations (CFR) Part 435 EPA-821-R-11-004 EPA-821-R-02-012

4.2.6. QA/QC

The organizational quality assurance unit (QAU) will remain independent of all work activities. The QAU will monitor the technical components of the project according to existing SOPs to ensure the accuracy, integrity and completeness of the data. Analytical staff members will be responsible for ensuring that sample tracking, sample preparation, and analytical instrument operation all meet QC criteria detailed in the applicable analytical SOPs.

4.2.6.1. Field-Based QA/QC

Standardized field documentation forms will be used to document all sample collection and handling activities, and to track electronically captured data. Field custody of electronic data will be the responsibility of the field survey's chief scientist and/or other responsible party on the vessel. The field custody of the electronic data consists of creating backups of all electronic data generated each day. The label on the backup media will include a survey ID, date, and name of person creating the backup files. Calibration and maintenance procedures for the sensors that will be used are included in the project-specific QAPP. The QAPP also describes the preparation of field QC samples such as field blanks and field duplicates.

4.2.6.2. Laboratory-Based QA/QC

An integral part of laboratory activities, QC lays out methods for maximizing the quality of operations and analyses, provides analysts with metrics about method performance, and aids project managers in identifying and correcting systematic and random problems that can plague laboratory operations.

A routine set of QC samples should accompany each set of samples analyzed at the laboratory. Details can be found in the project-specific QAPP.

The Measurement Quality Objectives (MQOs) for each QC parameter in this project are presented in the project-specific QAPP. Analytical results that do not meet the MQOs will be submitted to and/or reviewed with the project manager for assessment of the potential impact of the results. Affected samples may be reanalyzed at the project manager's discretion. QC sample data that are accepted outside the MQOs will be indicated with the appropriate data qualifier, and the rationale for accepting the analysis will be documented.

4.2.7. Sample Handling, Storage, Shipping and Custody

All samples will be inventoried in a field log book or electronic data acquisition program maintained by the project's chief scientist. All samples will be logged on CoC forms and will be stored in secure areas on the vessel(s) immediately after collection. Sample IDs will be cross-checked against the CoC logs prior to packaging samples in coolers for shipment to laboratories.

Sample integrity and custody will be maintained at all times. Every effort will be made to deliver samples to the laboratories in a timely manner with CoC forms inside each cooler. Established procedures will be followed and maintained throughout collection, packaging and shipping. Fully-executed CoCs documenting the sample receipt will be maintained by the laboratories.

5. REPORTING

5.1. First EMP Report

The first EMP report will be submitted no later than June 1 of the year following drilling site operation cessation. This EMP report will contain a preliminary analysis of site conditions during active drilling operations and an analysis of post-drilling conditions. Additionally, these data will be compared to existing baseline data.

5.2. Second EMP Report

The second EMP report will be submitted no later than June 1 of the year following completion of all drilling site monitoring. As per the NPDES permit, this EMP report will contain:

i. Summary of the results of all stages of environmental monitoring for each EMP phase;
ii. Discussion of how EMP goals and objectives were accomplished;
iii. Analytical test methods used for data analysis;
iv. Description of any impacts of the effluent on observed sediment pollutant concentration, sediment quality, water quality and benthic community;
v. Description of the data, evaluations and determinations with regard to each EMP phase; and
vi. All relevant QA/QC information including, but not limited to, laboratory instrumentation, laboratory procedures, analytical methods detection limits, analytical method precision requirements and sample collection methodology.

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APPENDIX A

Synthesis of Available Phase I Site Characterization Data for the Burger Prospect

APPENDIX A
SYNTHESIS OF AVAILABLE PHASE I SITE CHARACTERIZATION DATA FOR THE BURGER PROSPECT

EMP Plan of Study

Shell Outer Continental Shelf Lease
Chukchi Sea, Alaska

August 2013

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A: Burger A Pre-Drill Sediment Profile Imaging Survey

INTRODUCTION

As described in the Plan of Study, the Environmental Monitoring Program (EMP) is designed to meet the goals, objectives, and other requirements of U.S. Environmental Protection Agency (EPA) Permit No. AKG-28-8100; primarily, to evaluate the potential impacts of drilling discharges to the marine environment. The EMP is implemented using a four phased approach. The purpose of Phase I is to establish a baseline site characterization for proposed drilling sites. This characterization is intended to address very specific data quality objectives organized into four elements:

1. Conduct an initial site physical sea bottom survey to ensure that the drilling site is not located in or near a sensitive biological area or habitat;
2. Collect oceanographic information (e.g., surface winds, currents, sea water temperature, salinity, turbidity) in order to characterize the physical conditions of the drill site;
3. Collect chemistry data on natural parameters (e.g., dissolved metals, pH, total suspended solids) and potential contaminant parameters (e.g., metal contaminants of concern, total aromatic hydrocarbons, total aqueous hydrocarbons) in order to characterize the receiving waters; and
4. Describe the composition of the drilling site's benthic community, including infaunal and epifaunal invertebrates, bivalves, and crustaceans.

Since Shell is requesting authorization to discharge water-based drilling fluids and drill cuttings (Discharge 001), there is an additional baseline data requirement in Phase I of certain sediment characteristics (e.g., chemistry, grain size, and contaminant concentrations) and bioaccumulation data (i.e., baseline concentrations of contaminants associated with Discharge 001 in benthic and epibenthic invertebrate tissue) as per Part II.A.13.j.2 and II.A.13.j.3, respectively, of the Chukchi General Permit.

As provided for in the Chukchi General Permit, the Phase I baseline requirements may be fulfilled by submitting site characterization data collected recently and at or within the vicinity of the proposed drill site locations to EPA for consideration.

Permit No.: AKG-28-8100 Part II.A.13.f

Phase I Assessment – Physical site characterization data, collected by the permittee pursuant to other agency requirements or as voluntary actions, if collected within the most recent five-year period at or in the vicinity of the drill site location, may be submitted to EPA for consideration of meeting the Phase I data collection requirements. The permittee must submit the existing data along with the EMP Plan of Study.

The purpose of this document, therefore, is to provide a summary and synthesis of the recent site characterization data available for the six lease block locations within the Burger Prospect and demonstrate that the Phase I data collection requirements have been achieved. The document summarizes the types of data collected and the number and location of stations. In addition, the results from multiple years and locations are synthesized so that the existing "before drilling" physical and benthic biological conditions, including spatial and temporal variation, are clearly described.

Site characterization data from the past five years exist for the northeastern Chukchi Sea from two large, multi-year baseline studies programs and a small-scale sampling effort conducted by Shell in 2012. Information about these programs is provided below.

Chukchi Offshore Monitoring in Drilling Area – Chemistry and Benthos Program

The Chukchi Offshore Monitoring in Drilling Area (COMIDA) program is a comprehensive program funded by the Bureau of Ocean Energy Management (BOEM) that is designed to establish an integrated knowledge of the Arctic marine ecosystem within the northeastern Chukchi Sea, and specifically, within the Planning Area designated for oil and gas exploration and development. The Chemical and Benthos (CAB) component addressed the benthic system with a particular emphasis on trophic structure, sediment chemical characteristics, inventories of anthropogenic chemicals (trace metals and organics), and inventories of benthic biota, both infaunal and epifaunal. The Objectives included:

- To establish baseline data set for benthic infauna and epifauna, organic carbon and sediment grain size, radioisotopes for down core dating, as well as measure trace metals in sediments, biota and suspended particles; and
- To determine the sources, cycles and fate of carbon, selected trace metals and the role of trace metals on organic carbon dynamics and food web dynamics on the inner shelf of the Chukchi Sea

In 2009 and 2010, COMIDA CAB investigators traveled to the northeastern Chukchi Sea and collected water column hydrography, sediment cores for various chemical analyses and physical properties; water samples for total suspended solids, particulate organic carbon (POC), nutrients, and selected trace metals; benthic infaunal samples; epibenthic trawl samples, and biota (tissue) samples for chemical analyses (organic contaminants and metals). The cruise reports, principal investigators' presentations, seafloor video footage, data models, links to data archive sites, and the May 2012 Final Report are all included on the program's website: www.comidacab.org.

Building from the success of the COMIDA CAB project, a new study began in 2012 with a focus on the Hanna Shoal region. The Hanna Shoal Ecosystem Study is a multi-disciplinary investigation to examine the biological, chemical and physical properties that define this ecosystem. The study extends the monitoring initiated under the COMIDA CAB program, in which over 70 stations were occupied in the northern Chukchi Sea. The Hanna Shoal study adds (1) a pelagic component to address standing stocks of phytoplankton and zooplankton and (2) a physical oceanographic study that addresses water mass movements through direct measurement of circulation, density fields, ice conditions and modeling. In 2012, 73 distinct stations were occupied in the region. A similar number of stations have been sampled in 2013. Once data have been collected, analyzed, and quality controlled, maps and other data products will be made publicly available on the project website indicated above.

Chukchi Sea Environmental Studies Program

The Chukchi Sea Environmental Studies Program (CSESP), begun in 2008, is a multi-year, multi-discipline marine science research program in the northeastern Chukchi Sea. The overall purpose of the program is to provide the industry partners the necessary baseline site characterization data that can be used to conduct realistic evaluations on the potential impacts of oil and gas activities. Importantly, it will also contribute to the overall knowledge of the northeastern Chukchi Sea marine ecosystem. The studies program has included various scientific disciplines over time including: physical oceanography, chemical oceanography, plankton ecology, benthic ecology (infaunal and epibenthic communities), seabird ecology, marine mammal ecology, pelagic and demersal fisheries, and bioacoustics.

In 2008 and 2009, the program consisted of two prospect-specific Study Areas for ConocoPhillips and Shell, and in 2010, an additional prospect-specific Study Area was added for Statoil USA. The Study Areas, each consisting of a 900 square nautical mile area, are designated as Klondike, Burger and Statoil. The summary information and synthesis included in this document are primarily derived from work conducted within the Burger Study Area. In 2011, the studies program expanded to a larger area that encompassed the three prospect-specific Study Areas and Hanna Shoal to the north. In 2013, the studies program begins its sixth year building an integrated ecosystem data set.

Details about the science and the investigators as well as maps, presentations, and final reports are available through the program website at: www.chukchiscience.com. A special issue of the journal Continental Shelf Research is in press now and due out later in 2013. The issue focuses on the ecology of the northeastern Chukchi Sea and synthesizes information across the first 3 years of the study program (2008 – 2010) for each discipline and for the ecosystem as a whole.

Shell Discharge Monitoring Program

In 2012, additional site characterization data were collected by Shell at 18 localized stations in the Burger Prospect. Unlike other scientific programs conducted in the area, the DMP stations were distributed within a tight grid extending from 25m to 1500m from the Burger A drill site. The effort was part of a voluntary discharge monitoring program (DMP) conducted by Shell prior to implementation of the Chukchi General Permit.

All of the sampling locations within the Burger Prospect, from which sediment characteristic and benthic ecology data have been collected during these programs, are illustrated on Figure 1. Sample stations in the immediate vicinity of the Burger Study Area are also included. Not shown are the locations of cruise tracks from which physical oceanographic data were collected.

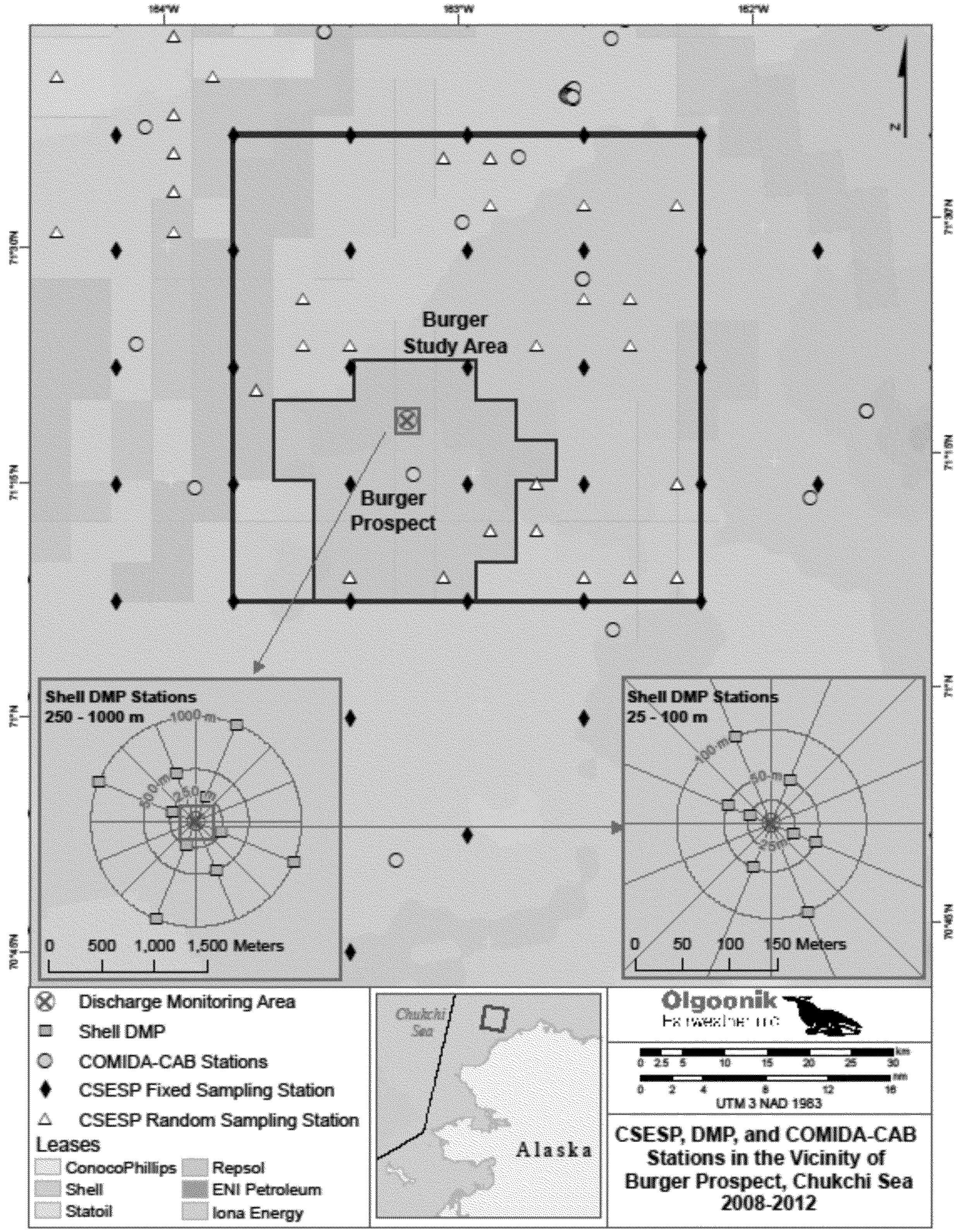


Figure 1: CSESP, DMP AND COMIDA CAB stations in the vicinity of Burger prospect, Chukchi Sea, 2008-2012.

The remainder of this document is organized to specifically address the four elements of Phase I:

Section 1 summarizes the available digital videos, sediment-profile imaging (SPI) photographs, and other photographs and benthic ecology data that fulfills the requirements for an initial site physical sea-bottom survey;

Section 2 summarizes physical oceanographic and sediment characterization data collected over the past five years and synthesizes this information into a concise description of the oceanographic and seafloor conditions within the northeastern Chukchi Sea region and at the Burger Prospect location;

Section 3 summarizes available receiving water chemistry analytical results and specifically addresses natural parameters (e.g., dissolved metals, pH, total suspended solids) and potential contaminant parameters (TAH and TAqH); and

Section 4 provides a synthesis of extensive site characterization data specific to benthic ecology at the Burger Prospect area and a discussion of several recent efforts to establish baseline bioaccumulation data in marine organisms.

1. INITIAL SITE PHYSICAL SEA BOTTOM SURVEY

Permit No.: AKG-28-8100 Part II.A.13.f.1

Initial Site Physical Sea Bottom Survey. Conduct an assessment of the physical sea bottom before initiating discharges authorized by the general permit to ensure the drilling site is not located in or near a sensitive biological area or habitat. The survey should provide both a physical and visual characterization of the seafloor. If the proposed initial site is located in a sensitive biological area or habitat, the permittee must find another well location and report the information to the Director in accordance with Section II.A.13.k.1.

The purpose of this section is to demonstrate that the proposed Burger Prospect drilling sites are not located in or near a sensitive biological area or habitat. Supporting information and available visible characterization data are presented.

Numerous intensive and broad-scaled benthic surveys have been conducted throughout the northeastern Chukchi Sea from the 1960s to the present. At this time, the only areas in Arctic Alaska's marine environment known to have sensitive biological habitat (i.e., particularly susceptible to impact or damage) are located where hard strata (boulders) predominate. These boulder patches are believed to have been deposited on the seafloor long ago (Dunton et al. 2009) and provide the foundation for a unique Arctic kelp ecosystem (Martin and Galloway 1994). For example, in Stefansson Sound (east of Prudhoe Bay) in the Beaufort Sea, patches of pebbles, cobbles, and boulders at cover densities of 10 to 25% have been intensively studied since the 1970s. In this area, known as the Boulder Patch, a variety of brown and red macroalgae have colonized the boulders forming one of the few known macroalgal beds along the Alaskan Arctic coast. Sessile fauna such as sponges, encrusting bryozoans, hydroids, soft corals, and tube worms thrive on the rocks and on macroalgal substrates (Dunton et al. 2009). This three-dimensionally structured, epilithic community provides a very unique Arctic marine habitat for a number of associated macro-organisms, including more than 150 species of macroalgae, invertebrates and fishes (Martin and Galloway 1994, Dunton et al. 2009) compared to 20 to 30 infaunal species (mainly polychaetes and amphipods) reported in surrounding areas. The Boulder Patch is a unique area of high biodiversity in an otherwise silt-mud dominated system that is devoid of the majority of these diverse faunal and floral groups (Martin and Galloway 1994).

In the northeastern Chukchi Sea, similar boulder patches have never been reported. Pre-drilling bathymetric and shallow hazard surveys have been conducted within the Burger Prospect and at specific proposed drill sites (in compliance with BOEM exploratory drilling requirements); the results of these surveys are presented in the Chukchi Sea Exploration Plan (Shell 2012). These surveys have not detected cobbles or boulders on the surface of the seafloor at a density that might indicate the possibility of a "boulder patch" benthic habitat.

In addition, digital videos, sediment-profile imaging (SPI) profile photographs, plan-view photographs, and benthic-ecology assessment data that were collected between 2008 and 2012 under the CSESP and Shell DMP also confirm that there are no "sensitive biological areas or habitats" that could be designated as critical or unique in the Burger prospect.

Plan-view and cross-sectional digital images and data collected in early August 2012 using SPI equipment are presented in the Burger A Pre-Drill SPI Survey Report (see Attachment A of this document). As discussed in the Attachment, examination of the photographs indicates consistent conditions in surface sediments throughout the Burger A survey area. Sediments at all survey stations appeared to be uniformly fine sand-silt-clay. Sediment compaction, as indicated by prism penetration depth, was uniform throughout the survey area. Plan-view camera images provided information regarding the sea bottom surface and associated benthic organisms. The dominant epifaunal taxon was the ophiuroid brittle star (ranging from 11 individuals/m^2 to 355 individuals/ m^2). Although turbid water (caused by storms) resulted in reduced visibility in certain instances, the images acquired in 2012 document conditions that are very similar to those from 2011. Video and plan-view images from the Burger Study Area, collected in 2011 using a camera sled (Figure 2) and in 2012 using the SPI equipment (Figure 3), indicate fine-grained, muddy sediments with the surface dominated by the brittle star *Ophiura sarsi,* a brittle star with a broad circumpolar distribution (Bluhm et al. 2009).

SPI profile photographs depict an upper layer of light tan-colored sediment indicating biologically-active infauna (invertebrate animals residing within the sediments) and darker sediments below with tube-dwelling infauna. In particular, it appears that the survey area has well developed and mature infaunal communities – a finding that is consistent with many years of benthic sampling within the Burger Study Area (see Section 4 of this document). Thus the SPI photographs confirm a depositional environment and benthic habitat conditions expected for this part of the northeastern Chukchi Sea.

Certain news releases in 2012 suggested that sensitive species, specifically soft corals, were newly discovered in the Burger Study Area and represented a critical habitat at the drilling locations (see http://www.greenpeace.org/usa/en/media-center/news-releases/Abundant-corals-discovered-at-Shells-Chukchi-drill site/). The soft coral in question, the Sea Raspberry (*Gersemia fruticosa* and *G. rubiformis*), is well-known and widely dispersed throughout the north Pacific, the Bering Sea, Alaska's coastal waters, and the Chukchi Sea. Based on the extensive CSESP sampling efforts from 2008 to 2012, there do not appear to be any habitats or species that can be designated as critical or unique in the Burger Study Area or at the Burger Prospect. Additional support for this conclusion can be found in the rejection of "petition to list 44 coral species under the Endangered Species Act (ESA)" published in February 2013 in the Federal Register (Federal Register, Volume 78 Number 31).

In summary, the information presented in this section supports Shell's conclusion that there are no known sensitive biological habitats or areas in the Burger Prospect area and that the information collected to date fulfills the requirement for an initial site physical sea-bottom survey at the proposed Burger Prospect drill sites.

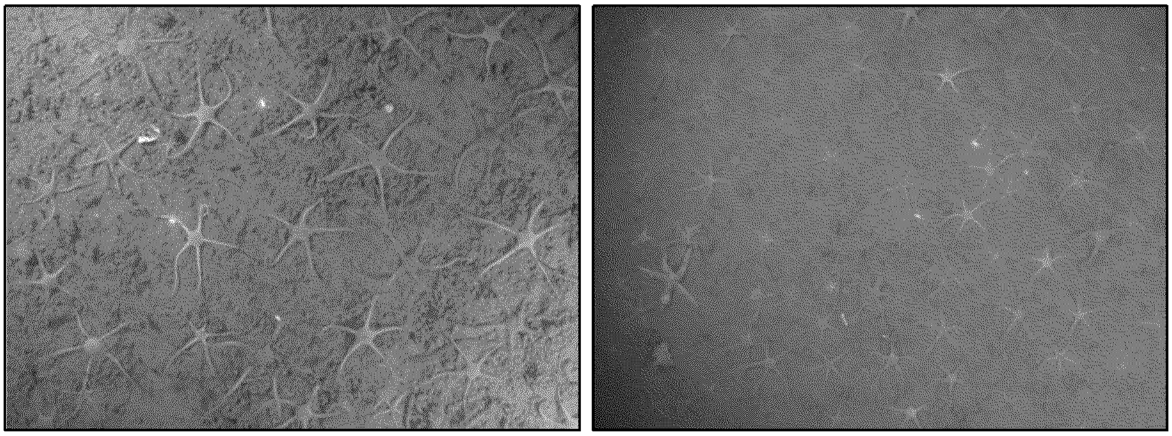


Figure 2: Digital still photographs (showing an area 50cm x 28cm or 0.14 m^{-2}) extracted from videos taken during 2011 in the Burger Study Area. The red dots are 10 cm apart.

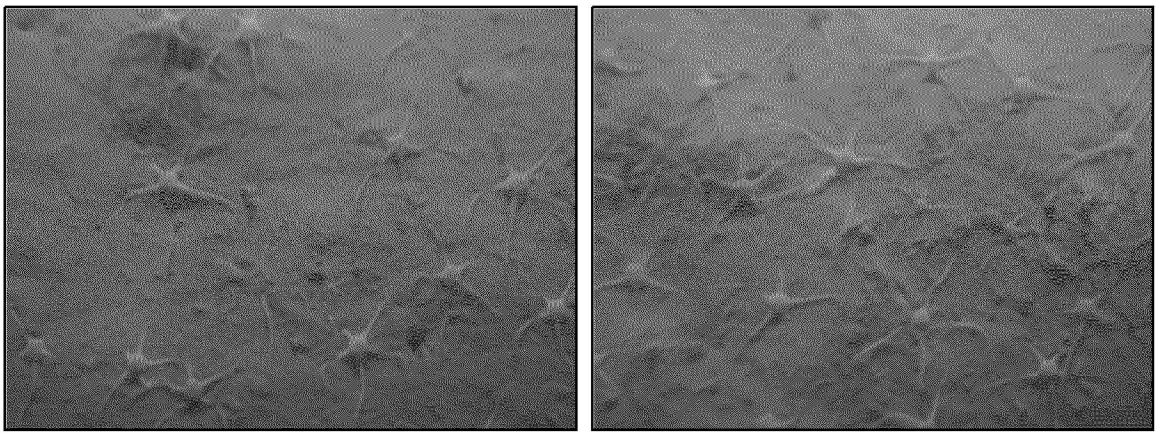


Figure 3: Digital images taken in 2012 from the Burger A drill site in 2012 using SPI equipment. The red dots (enhanced) are 10 cm apart. Source: John Hardin, Battelle.

2. PHYSICAL CHARACTERISTICS

Permit No.: AKG-28-8100 Part II.A.13.f.2

Physical Characteristics. Collect physical data to characterize the conditions of the drilling site and receiving waters. These physical data include surface wind speed and direction, current speed and direction throughout the water column, water temperature, salinity, depth, and turbidity.

The purpose of this section is to summarize the available physical oceanographic and sediment characterization data and synthesize this information into a concise description of the conditions at the drill sites and receiving waters. The regional oceanography of the northeastern Chukchi Sea is presented first and then specific information about the physical characteristics at the Burger Prospect is provided.

2.1. Regional Oceanographic Conditions

The basic physical oceanographic conditions of the northeastern Chukchi Sea are well-known because of a variety of year-long, subsurface oceanographic moorings that began in the 1980s and numerous shipboard measurements collected over many years. It is generally accepted that North Pacific Ocean waters are transported through the Bering Strait, across the Chukchi continental shelf and into the Arctic Ocean. This circulation is primarily driven by water flowing "downhill" from the higher sea level in the Pacific Ocean to the lower sea level in the Arctic Ocean.

Although relatively shallow (40 to 50 m deep), the general northward flow of water does not proceed uniformly across the Chukchi continental shelf because distinctive shelf features "guide" the flow and the distribution of water masses (Figure 4). These features include Herald Shoal, located in the center of the shelf, with a diameter of about 100 km and minimum depths of about 20 m, a relatively shallow north-south oriented depression called the Central Channel, and Hanna Shoal, about 100 km long and 75 km wide, with minimum depths of about 25 m.

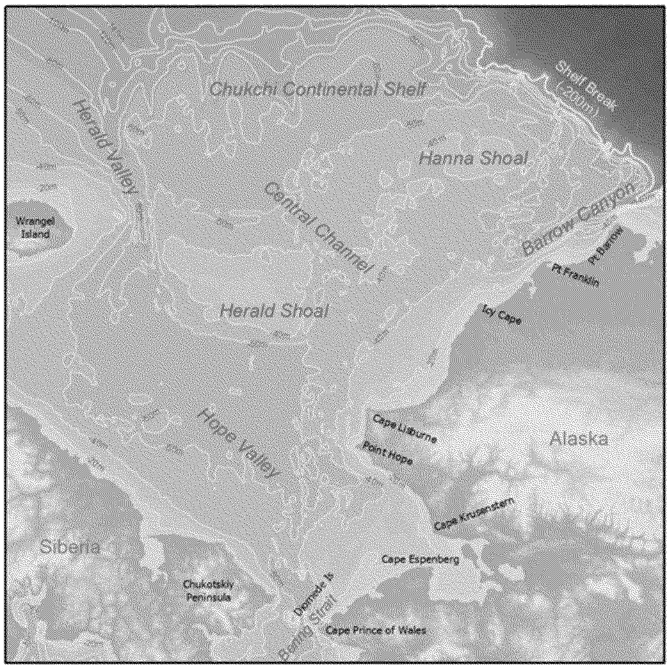


Figure 4: Distinctive shelf features of the Chukchi continental shelf.

Multiple past investigations have demonstrated that the flow of ocean water occurs along three main branches – each associated with a particular bathymetric feature (Figures 4 and 5). The first branch is composed of flows occurring northward through the Bering Strait and continuing northwestward through Hope Valley and into Herald Valley. While most of this outflow continues to the shelf break, some of it may spread onto the shelf north of Herald Shoal and drift eastward toward the central shelf.

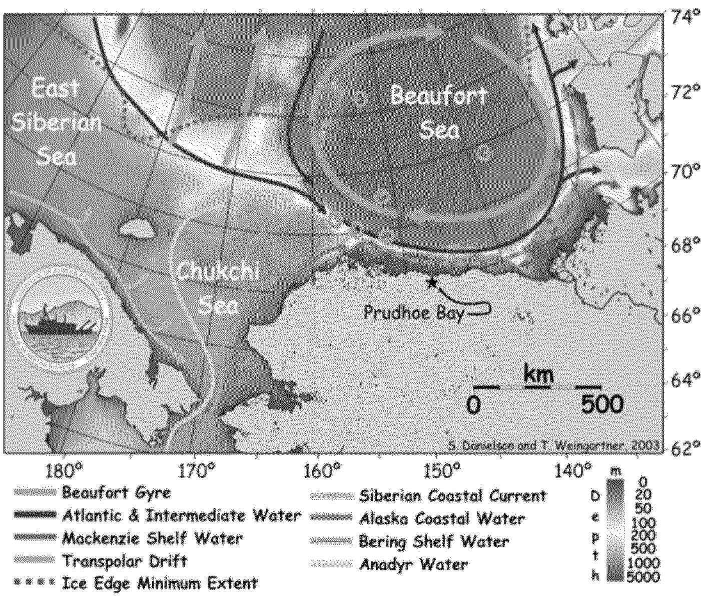


Figure 5: Flow of ocean water in the East Siberian Sea, northeastern Chukchi Sea, and Beaufort Sea.

The second branch flows northeastward along the Alaskan coast towards Barrow Canyon. In the summer, this flow includes the northward extension of the low-salinity and nutrient poor Alaskan Coastal Current flowing through the Bering Strait. The Alaskan Coastal Current begins in British Columbia, Canada and southeastern Alaska as freshwater runoff discharges into the sea. Due to the Earth's rotation, this discharge is forced west and north traveling along Alaska's coast through the Gulf of Alaska, Bering Sea and eventually into the Chukchi and Beaufort Seas. The current maintains its low salinity, warmth, and nutrient-poor characteristics as warmer river discharges are incorporated. At Barrow Canyon, the Alaskan Coastal Current merges with waters flowing eastward from the central Chukchi shelf while proceeding down the Canyon toward the shelf break.

A third branch, of moderate salinity and nutrient load, flows northward through the Central Channel. Some of this water moves eastward along the south side of the Burger Prospect and eventually enters Barrow Canyon, while another fraction continues northward toward the outer shelf west of Hanna Shoal.

The nutrient and carbon loads carried along these branches differ. In the summer, the Herald Valley outflow is saltier, colder, and richer in nutrients and marine-derived carbon than the waters transported in the Alaskan Coastal Current along the Alaskan coast. The properties of the waters crossing the central shelf, including the Burger Prospect discussed below, fall between these extremes.

In addition to Pacific Ocean water, there are three distinct water masses that form seasonally or intrude occasionally in the northeastern Chukchi Sea, including the Burger Prospect area. These are the (1) sea ice meltwater pools, (2) upwelled continental slope waters, and (3) water masses that originate as a result of the formation of recurring polynyas.

The first water mass consists of the meltwaters produced as sea ice melts and/or retreats across the shelf from summer through fall. These are relatively cold but low-salinity waters, having much lower density than the cold, saline deeper waters remaining from winter or the relatively warm Pacific waters transported northward from Bering Strait in the summer. Meltwater masses form 10 to 20 m thick, heavily stratified pools that are separated from ambient shelf waters by 10 to 20 km wide fronts. These pools and fronts are prominent along the perimeter of the ice edge. They may remain at both Hanna and Herald Shoals for several weeks after ice has disappeared due to the relatively weak circulation atop the shoals. The weak circulation atop the shoals also results in greater amounts of ungrazed plankton material falling onto the shoal and surrounding area, which in turn supports an abundance of clams and other benthic organisms. Not surprisingly, the residual sea ice that persists in the vicinity of Hanna Shoal is used by Pacific walrus to haulout while feeding on the rich benthic fauna present in the vicinity of Hanna Shoal.

The second water mass consists of upwelled continental slope waters that occasionally intrude onto the northeast Chukchi continental shelf through Barrow Canyon. These are upwelled into the Canyon from depths of 150 m or greater most frequently in fall and winter during strong northeasterly wind events. On occasion, the upwelled slope water includes deep (approximately 250 m) relatively warm, salty water whose original source was the Atlantic Ocean. Typically, these upwelling events last a few days before the upwelled water drains back down the Canyon.

Most of these events are confined to the Canyon proper, but on occasion continental slope water reaches the head of the Canyon and spills onto the Chukchi shelf.

The third distinct water mass originates as a result of the formation of recurring polynyas. Polynyas are open water areas surrounded by sea ice that form under freezing atmospheric conditions. The largest and most frequently formed polynyas develop in the Chukchi Sea along the northwest coast of Alaska during winter episodes of cold, offshore winds. The winds push sea ice offshore, allowing surface seawater to lose heat to the atmosphere. Since the seawater is already at the freezing point, cooling also results in rapid formation of new ice, which is continuously swept downwind by the wind so that the polynya remains open. Once the winds weaken sufficiently or reverse direction, the polynya freezes over. Although large volumes of ice can be produced in polynya, their development is episodic since it depends upon large-scale weather systems. The salinity (and density) of the waters within the polynya increases greatly because salt is expelled from newly forming ice crystals. The resulting cold, saline waters contribute significantly to the volume of winter water formed on the Chukchi shelf.

Although the annual temperature and salinity cycles between the Chukchi Sea and Bering Strait are very similar, the near bottom winter waters on the Chukchi continental shelf, including the Burger Prospect area, remain saline and close to the freezing point longer than those waters in more southern areas of the Chukchi Sea and the Bering Strait. In part, this is due to the longer freezing season, but it also reflects the time required for cold, saline deep waters moving northward from the Bering Sea to traverse the Chukchi continental shelf. Moreover, winter waters are replaced much more slowly around the Hanna Shoal region than along the main flow pathways.

Chukchi Sea waters are eventually flushed into the Arctic Basin and/or into the Alaskan Beaufort Sea. The low density Chukchi summer waters enter the upper 50 m of the Arctic Ocean basin, whereas denser winter waters typically descend to 100 to 200 m depth in the Arctic Basin. Here they contribute to the maintenance of the Arctic Ocean's halocline, a salt-stratified layer that separates the fresh, cold surface waters from relatively warm and salty deeper waters originally derived from the Atlantic Ocean.

In summary, circulation in the Chukchi Sea is controlled largely by the opposing tendencies between the pressure gradient that forces water northward though the Bering Strait and across the Chukchi continental shelf and the predominant wind systems that force water southward. The location of various branches of this northward flow of water is primarily due to the shelf topographic features such as the Central Channel and Hanna Shoal.

2.2. Burger Prospect Oceanographic Conditions

Physical data collected for the past five years in the OCS Chukchi Sea under the CSESP and COMIDA programs include surface wind speed and direction, current speed and direction throughout the water column, water temperature, salinity, depth and turbidity. Data collected from the northeastern Chukchi Sea over the past five years include shipboard measurements of vertical profiles of temperature and salinity, velocity measurements from year-round oceanographic moorings, satellite-tracked drifters, and shore-based surface current-mapping radars that are operating during the open-water season from August through late October. These data are supplemented by historical data sets (shipboard and moorings only) from the northeastern Chukchi Sea shelf. This information has been reported by Coachman et al. (1975), Martin and Drucker (1997), Weingartner et al. (1998, 2005, In press), Winsor and Chapman (2004), Woodgate et al. (2005a, 2005b), Pickart et al. (2005), Spall (2007), Mudge et al. (2010), and Timmermans and Winsor (2013). In addition, several publicly-accessible websites provide additional information and data, some of which (e.g., meteorological reports, data from shore-based current-mapping radars, satellite drifters) provide data in real-time during the open-water season. These websites include:

http://www.ims.uaf.edu/hfradar/ ;

http://dm.sfos.uaf.edu/chukchi-beaufort/data/drifters/ ; and

http://www.ims.uaf.edu/chukchi/ .

2.2.1. Water Depth

Bathymetric data and individual sampling station data from both the CSESP and COMIDA CAB studies demonstrate that water depth is well characterized in the Chukchi Sea and within the Burger prospect. Water depths in the Burger prospect are shallow and consistently range from 40 to 50 m.

2.2.2. Temperature and Salinity

The temperature and salinity properties of the Chukchi shelf undergo seasonal transitions that are a consequence of freezing and thawing (largely governed by the annual cycle in solar radiation) and transport of water masses northward from the Bering Sea. In the summer and fall months, Bering Sea summer waters are an important source of heat that accelerates ice retreat (in summer) and delays fall ice formation. By the end of the winter, water column temperatures are vertically and nearly horizontally uniform at the freezing point of seawater (approximately −1.7 degrees Centigrade [°C]). Salinity also is vertically uniform at this time and ranges from 32 to 33 parts per thousand (ppt). By early summer, these dense waters, all of which were formed during the previous winter, are found across the entire northeastern Chukchi shelf. As ice-melt begins in spring, the water column stratifies because the surface layer is diluted by fresh ice meltwater that is less dense than the salty bottom waters. Depending on mixing and the rate of ice-melt, the upper 5-15 meters (m) of the water column has salinities between 27 and 30 ppt. Spring and mid-summer surface temperatures can range from approximately −1°C to approximately +4°C, with the warming largely being a consequence of solar warming of the meltwater. Through July, much of the northeastern Chukchi shelf, and the Burger Study Area in particular, is characterized by a strongly salt-stratified water column. By August, the stratification of the northeastern Chukchi shelf weakens with the arrival of less stratified, moderately salty, and warm waters from the Bering Sea. These waters infiltrate the Burger Study Area from the west and south, leading to a reduction in stratification as surface meltwaters and dense winter bottom waters gradually are displaced from the region. Within the Burger Study Area, the replacement of these water masses typically is completed by mid- to late September. The erosion in stratification also is accelerated in fall as wind speeds increase (generally) and solar heating diminishes, and the water column typically is well-mixed again by mid-October. An example of the August-September transitions in water column temperature and salinity over the northeastern Chukchi Sea (including Burger prospect) is shown in Figure 6.

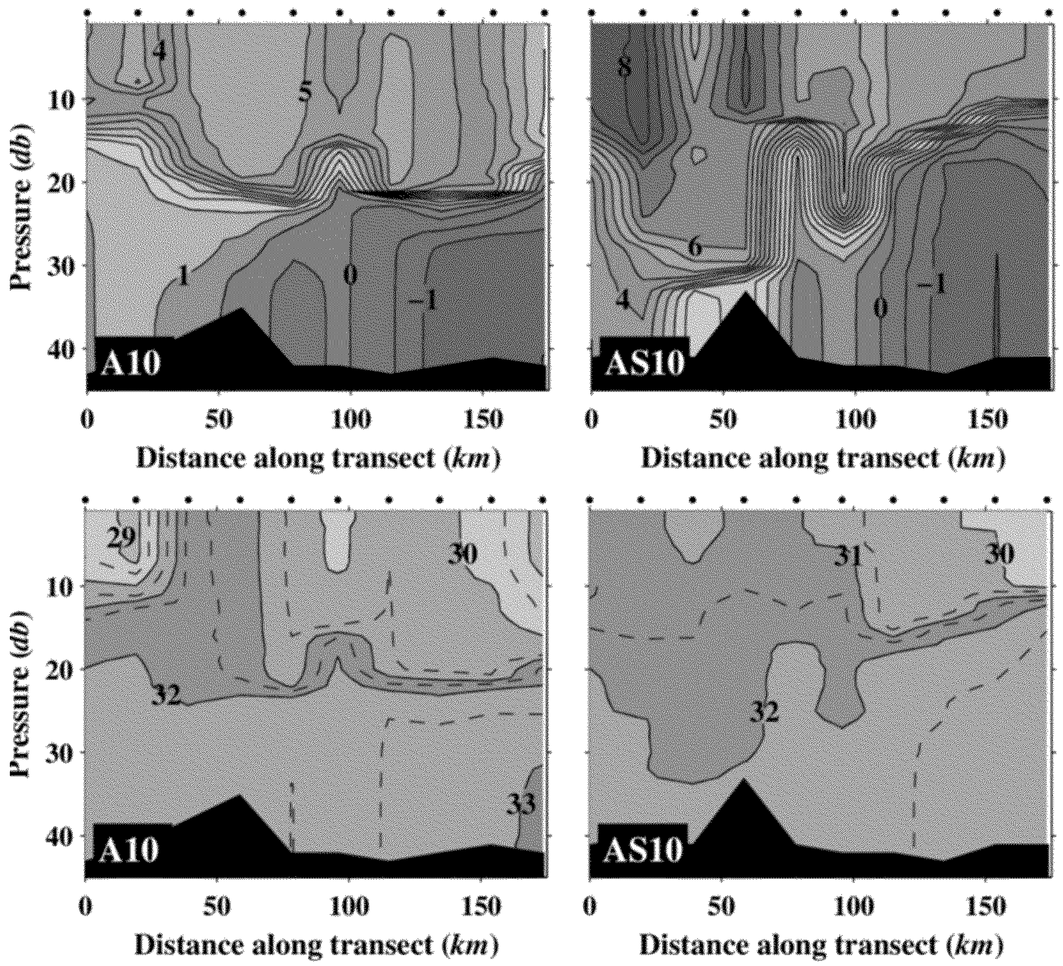


Figure 6: Temperature (top) and salinity (bottom) cross-sections across the northeastern Chukchi Sea in early August (A10; left) and late August to mid-September (AS10; right), 2010.

2.2.3. Currents and Wind

Although a large-scale forcing factor drives water flow northward, this flow is against the predominant northeast surface winds that tend to force water flow to the southwest. Therefore, temporal variations in current strength and direction can be significant – especially in the presence of strong winds. Sufficiently strong storms can reverse the flow to the southwest over broad portions of the shelf, including the Bering Strait region. The wind influence is greatest, however, at the surface and decays rapidly with depth so that currents may vary in magnitude and direction with depth. Under moderate to strong winds, the surface waters are expected to move downwind while the sub-surface flow would weaken – but still flow upwind.

At the Burger Prospect, mean current speeds during the ice-free season range between 5 and 10 centimeters (cm) per second (s^{-1})(0.1-0.2 knots [kt]) and flow toward the east. The variability of the current strength is related primarily to variations in the strength and direction of the winds.

On average, winds blow from the eastern (northeast, east or southeast) octants about 45% of the time in July, with this percentage increasing to 60% in October. The frequency distributions of winds blowing from the other octants are roughly comparable in these months, with each octant accounting for 5 to 10% of the total. The existing data suggest that the flow begins to reverse (at least at the surface) when winds from the east or northeast exceed ~6 m s^{-1} (12 kt). Winds generally are weak during July and August, when <30% of the winds speeds from the eastward octants exceed 6 m s^{-1}. Hence, currents at the Burger Prospect tend to be comparable to the mean about 70% of the time during these months. In September and October, wind speeds exceeding 6 m s^{-1} occur about 35% of the time. This increase in wind strength is associated with an increase in current variability. Currents vary principally between being eastward and westward in the Burger prospect. As a consequence of fall storms, the mean flow conditions occur ~40-50% of the time in September and October. Maximal wind-driven current speeds are 40-50 cm s^{-1} (0.8-1.0 kt) and may persist for periods of two to several days. Although these larger currents may occur anytime during the open-water season, they are more common in the fall when stronger winds associated with fall storms move through the region. The velocity field also is highly correlated spatially over the northeastern Chukchi shelf. In general, there is little velocity difference (shear) between surface and subsurface layers of the water column. However, the magnitude of the velocity shear depends upon the strength of the stratification, in that strongly stratified waters tend to have greater shear because stratification traps the momentum imparted by the winds to the surface layers.

In conjunction with the existing data sets for the Chukchi Sea, shore-based radars operate throughout the open-water season. The current data generated from the shore-based radars includes data covering the Burger prospect. These data are publically available in real-time on the internet at http://www.ims.uaf.edu/hfradar/animation/.

2.2.4. Turbidity and Total Suspended Solids

Data from COMIDA CAB indicate that the concentrations of total suspended solids (TSS) in the upper 30 m of the water column for the combined 2009 and 2010 data set for the northeastern Chukchi Sea (n = 84) averaged 0.27 ± 0.18 (standard deviation [SD]) milligrams per liter (mg/L) with a range of 0.07 to 0.74 mg/L (Table 1). In the Burger Study Area, TSS values averaged 0.31 ± 0.23 mg/L and ranged from 0.13 to 0.38 mg/L, for water depths in the upper 30 m. In contrast, at water depths greater than 30 m, values for TSS in the northeastern Chukchi Sea during both 2009 and 2010 averaged 1.8 ± 0.8 (SD) mg/L, almost seven times higher than found in the upper water column (Table 1). In the Burger Study Area, TSS averaged 1.1 ± 0.57 mg/L and ranged from 0.73 to 1.54 mg/L for water depths greater than 30 m. Most vertical profiles for TSS show a clear trend of lower values in surface water and distinctly higher values below the pycnocline, in the lower 20 m of the water column. As previously mentioned, bottom currents in the eastern Chukchi Sea have an annual average flow of ~5 to 10 cm s^{-1} with maximal values as high as 45 cm s^{-1} (Weingartner et al. 2005), sufficient to re-suspend bottom sediments. A strong pycnocline and shear across that density boundary seem to confine re-suspended sediments to the bottom 20 m of the water column. Lower values for TSS in surface water also are limited by a minor influx of river runoff to the northeast Chukchi Sea.

Table 1: Summary data for total suspended solids collected from the Chukchi Sea during the 2009 and 2010 COMIDA surveys.

	2009	2010	2009	2010	2009	2010
	<30 m	<30 m	>30 m	>30 m	>30/<30 m	>30/<30 m
Total Suspended Solids (mg/L)						
Mean	0.29	0.26	2.41	1.55	8.4	5.9
SD	0.19	0.17	0.96	0.55	-	-
N	34	50	14	25	-	-
Max	0.69	0.74	4.29	2.47	-	-
Min	0.08	0.07	1.23	0.73	-	-

The composition of the suspended particles also was distinctly different in surface versus bottom water. For example, concentrations of particulate Al (as a % of TSS) averaged 1.0 ± 0.9% in the upper water column vs. 3.8 ± 1.8% for samples collected at greater than 30 m water depth during 2009 and 2010. This trend was consistent with greater amounts of re-suspended aluminosilicates (silt and clay minerals) than would be expected in the lower water column relative to the upper water column. In contrast with the trend for particulate Al, concentrations of particulate organic carbon (POC) as a % of TSS for 2009 plus 2010 averaged 19 ± 9% at water depths <30 m and 9 ± 7% at water depths >30 m (Table 1). Thus, more organic-rich and clay-poor particles were collected from the upper part of the water column and vice versa for the lower part of the water column (Table 1).

2.3. Sediment Characteristics

Section II.A.13.j.2 of the Chukchi Sea General Permit requires baseline data for sediment characteristics associated with authorization of Discharge 001. Baseline concentrations of potential contaminants in sediments are therefore needed to determine whether anthropogenic inputs of the contaminants are present in samples collected in Phase III or Phase IV field efforts. Because trace metals and hydrocarbons occur naturally in the environment at different concentrations, the process of establishing baseline values can be challenging. In this section, concentration data for metals and hydrocarbons in sediments are presented; analytical results from the larger northeastern Chukchi Sea region are presented first and then compared to the Burger Prospect specific results. This comparison is presented in order to demonstrate that useful baseline values already exist for the Burger Prospect area.

2.3.1. Metals

More than 300 sediment samples from the northeastern Chukchi Sea have been collected and analyzed for 19 metals. This data set includes 69 samples from the Burger Study Area (square marked B in Figure 7) and 259 samples from outside of the Burger Study Area, in the northeastern Chukchi Sea (Figure 8, Table 2). A five-fold range in concentrations of Al and other metals has been found throughout the northeastern Chukchi Sea (Figure 9A). The lowest concentrations of Al were found near the coast in sand and gravel and in the sandy sediments of

Hanna Shoal. The highest concentrations of Al were found offshore in silt- and clay-rich sediments (Figures 9A and 9B). The distribution of fine-grained sediment (silt + clay) follows that observed for Al (Figure 9A) because fine-grained sediment contains Al-rich clays (i.e., aluminosilicates). Therefore, concentrations of Al are positively correlated with silt + clay content because concentrations of Al are very low in coarse-grained quartz sand and carbonate shell material and are much higher in fine-grained aluminosilicates. Sediment concentrations of Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Sn, V and Zn also varied considerably throughout the northeastern Chukchi Sea; however, they were strongly correlated (r = 0.7-0.9) or very strongly correlated (r > 0.9) with concentrations of Al (e.g., Cr, Zn and Hg in Figures 9B, C and D) and thus followed the same geographic trends described for Al (Figure 9A). The relationship between absolute concentrations of Al and trace metals can be explained by variations in grain size, TOC and/or mineralogy because these three variables control metal concentrations in sediments (Trefry et al. 2003). This relationship can then be used to determine baseline metal concentrations in sediments from the northeast Chukchi Sea.

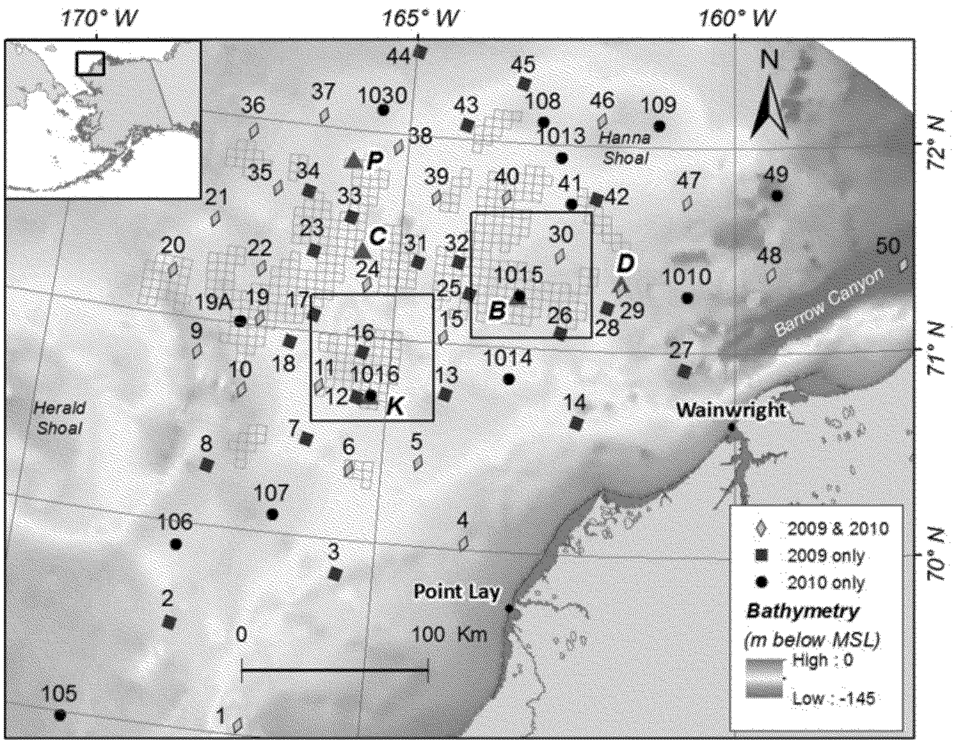


Figure 7: Location of sediment sampling stations in the northeastern Chukchi Sea. The stations identified with markers were sampled as part of the COMIDA project (Dunton et al. 2012). The two squares identify the Burger (B) and Klondike (K) Study Areas.

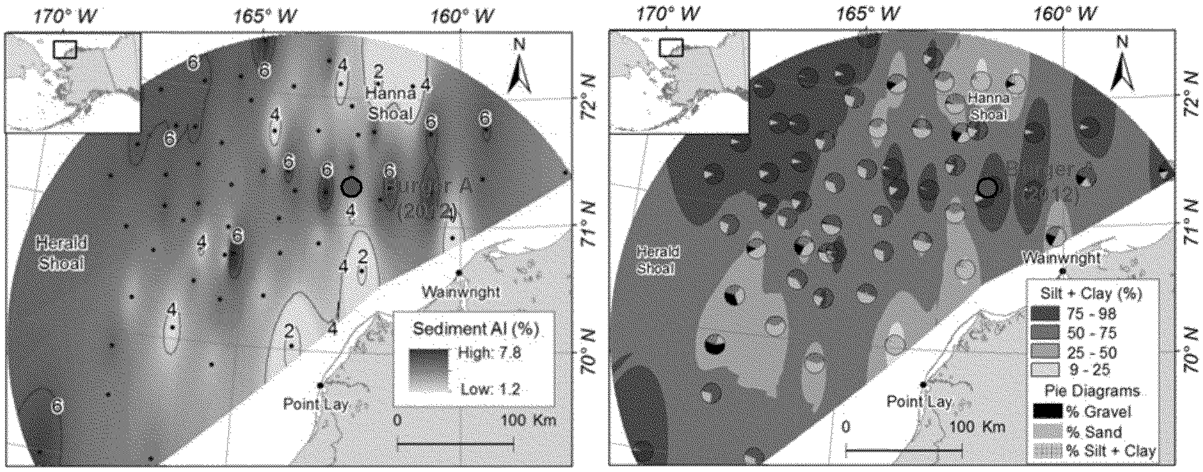


Figure 8: Contour maps for (A) concentrations of aluminum (%), and (B) % silt + clay with pie diagrams showing gravel (black), sand (blue) and silt + clay (cross-hatched) in surface sediments. Solid circles show the 58 stations that were used to determine baseline metal concentrations in sediments from the northeast Chukchi Sea. Red circle shows location of the Burger A drill site.

Table 2: Summary of sediment and biota samples collected in the northeastern Chukchi Sea, including the 2012 Burger A drill site.

Area	Year Collected	# Surface Sediment Samples	# Samples from Cores (# cores)	# Pools of Clam Samples (*Astarte* spp.)	# Water Samples (filtered)
NE Chukchi Sea					
Burger A drill site	2012	18	-	17	-
Burger Study Area	2008-2010	46	23 (3)	17	6
Northeastern Chukchi Sea	2009-2012	76	183 (12)	5	88

A reliable and well-accepted method for identifying background metal concentrations in marine sediments has been developed – by normalizing metal concentrations to Al, the most abundant metal in marine sediments (Bruland et al. 1974; Trefry and Presley 1976; Schropp et al. 1990; Trefry et al. 2003). This is based on the assumption that, without detectable anthropogenic inputs, natural concentrations of metals will plot within the 99% prediction intervals (calculated from linear regression analysis), as shown on plots of individual metals vs. Al concentrations (e.g., Figure 9). The prediction intervals on these plots of individual metals vs. Al concentrations can therefore be used to define baseline metal concentrations throughout the northeastern Chukchi Sea, including the Burger Prospect area.

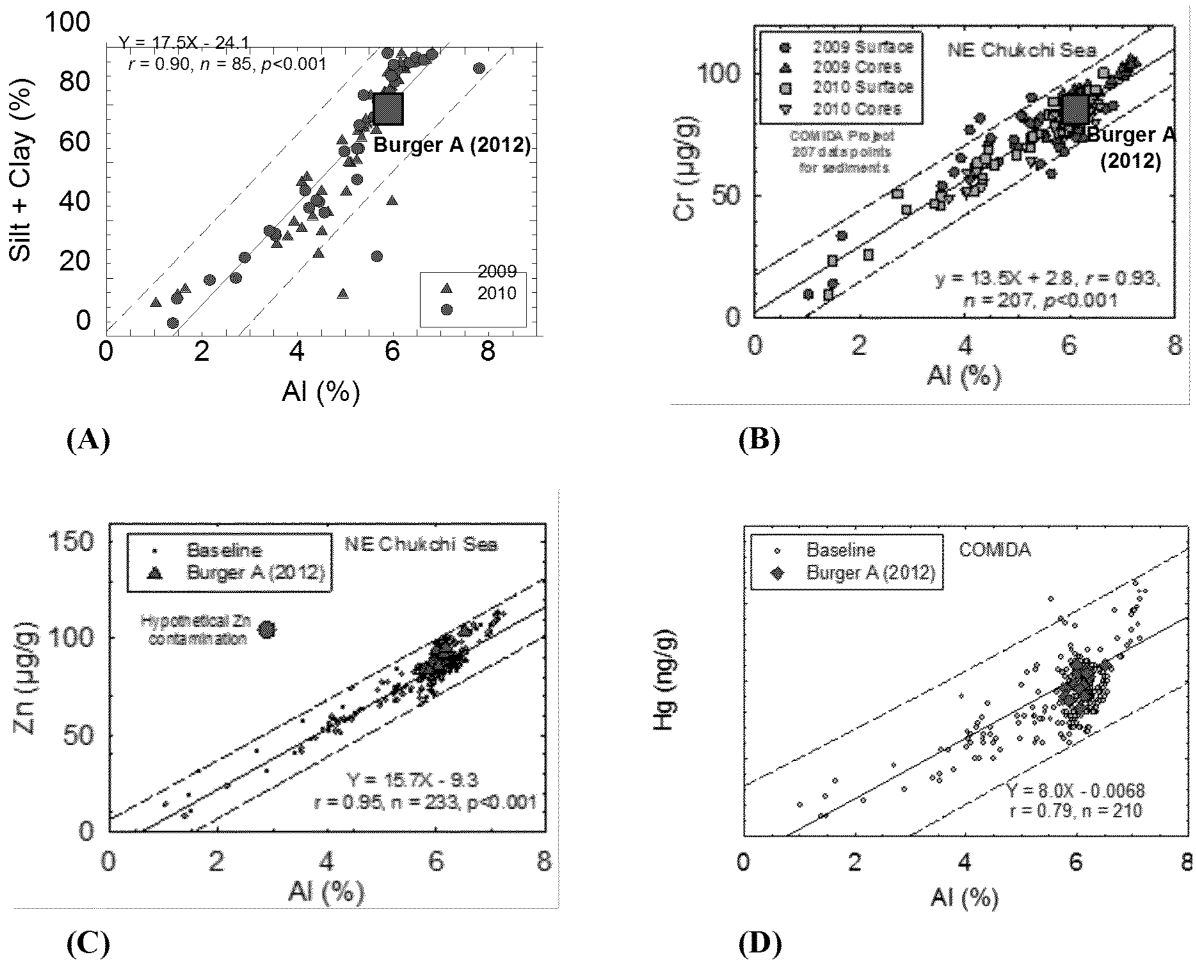


Figure 9: Concentrations of (A) silt + clay vs. Al, (B) Cr vs. Al, (C) Zn vs. Al, and (D) Hg vs. Al, for surface sediments from baseline stations throughout the northeastern Chukchi Sea. Equations and solid lines are from linear regression calculations for the 2009-2010 data from the COMIDA project (Dunton et al. 2012); dashed lines show 99% prediction intervals; *r* is the correlation coefficient; *n* is the number of samples; and *p* is the probability factor.

For the northeastern Chukchi Sea, a complete series of 17 graphs of metal concentrations vs. Al concentrations, such as those in Figures 9B, C and D, have been prepared (Trefry et al. 2012) to define baseline concentrations for 17 of the metals listed in Table 3. In other words, a master baseline for the northeastern Chukchi Sea has been established for essentially the same metals listed by the U.S. EPA for analysis at proposed drill sites (the one exception is Ti). Naturally occurring metal concentrations in samples collected from a new location in the northeastern Chukchi Sea, such as any of the six proposed Burger drill sites, should plot within the established prediction intervals on the relevant graph. Significant and positive deviations from the linear trend, such as shown by a hypothetical example for Zn contamination (Figure 9C), can then be used to identify metal contamination (or diagenetic remobilization) as described in more detail within Trefry et al. (2003).

The metal concentrations in surface sediments from the Burger A drill site are very uniform. The concentrations of 19 metals in 18 sediment samples collected from the Burger A drill site during

2012 had an average relative standard deviation (RSD) of ~7% (Table 3; also see sampling locations in Figure 1). This represents very low variability between samples for most metals of potential concern and further supports the concept that sediment characteristics within the Burger Prospect are very consistent. For Ag, Cd and MeHg, RSDs >10% were due in part to the very low natural concentrations of these metals. The high RSD for As was due to As enrichment in surface sediments at a few stations due to natural diagenetic processes (see Table 1 in Trefry et al. 2010).

The data in Table 3 can be considered to represent baseline metal concentrations for the Burger Prospect, especially when used in conjunction with the master baseline data set for the northeastern Chukchi Sea described above.

Table 3: Concentrations of metals (mean ± SD) in sediment samples from 2012 study of Burger A drill site.

Parameter (n = 18)	Ag (µg/g)	Al (%)	As (µg/g)	Ba (µg/g)	Be (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (%)	Total Hg (ng/L)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD[1]	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

Parameter	MeHg (ng/g)	Mn (µg/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Sn (µg/g)	Tl (µg/g)	V (µg/g)	Zn (µg/g)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD[1]	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

[1]RSD = (SD/mean) x 100%.
Mn = manganese
V = vanadium

2.4. Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are the class of hydrocarbons that generally are of greatest interest from an environmental, ecological and toxicological perspective. Total PAH data for 29 sediment samples collected from the Burger Study Area in 2008 and 20 sediment samples collected from the Burger A drill site area in 2012 were therefore analyzed in order to establish a baseline hydrocarbon site characterization for the Burger Prospect. Sample locations are shown in Figure 1. The hydrocarbon data was compiled, analyzed and summarized with selected statistical methods and also plotted to compare concentrations within and among these data sets.

When comparing data between studies, it is important that the data (e.g., target analytes and analytical methods) are comparable and that any differences in methods are understood and can be accounted for. The 2008 Burger Study Area and 2012 Burger A drill site sediment samples were collected the same way, were analyzed by the same laboratory with the same methods, and can be compared with confidence. The samples were collected to represent the top 2 cm of the surface sediment, the target analytes were the same, and the analytical methods used were the same. A total of 42 PAH parameters, including several alkylated PAH homologous series, were measured in the Total PAH analysis. The Total PAH analytical results for the two Chukchi Sea datasets are summarized in Table 4. The mean concentrations for the Total PAH compounds are presented along with the SD and the minimal (Min) and maximal (Max) sample concentrations. These data also are presented graphically in Figures 10 and 11.

Table 4: Summary of concentrations of hydrocarbons (µg/kg dry weight [DW]) in the upper 2 cm of sediments at the Burger Study Area (2008) and the Burger A drill site (2012) in the Chukchi Sea.

	Burger Study Area (29 samples)				Burger A drill site (20 samples)			
Hydrocarbon parameter	Mean	SD	Min	Max	Mean	SD	Min	Max
Total PAH (Σ42)	300	93.1	121	482	304	25.0	264	365

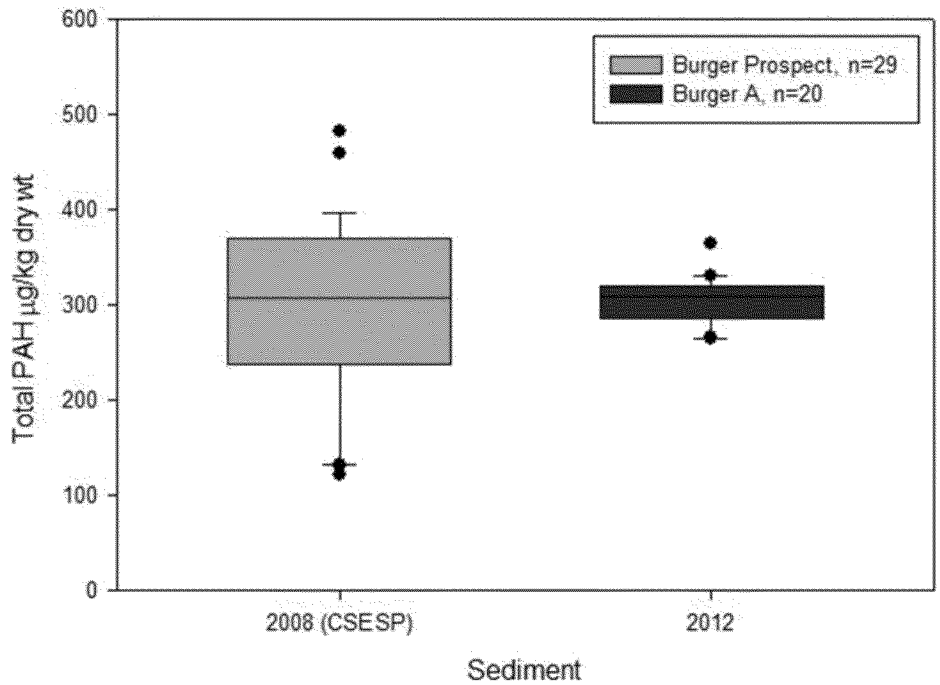


Figure 10: Summary of Total PAH concentrations (µg/kg DW) in sediment samples from the Burger Study Area (2008) and the Burger A drill site (2012) of the Chukchi Sea. Horizontal line in the box represents the median value.

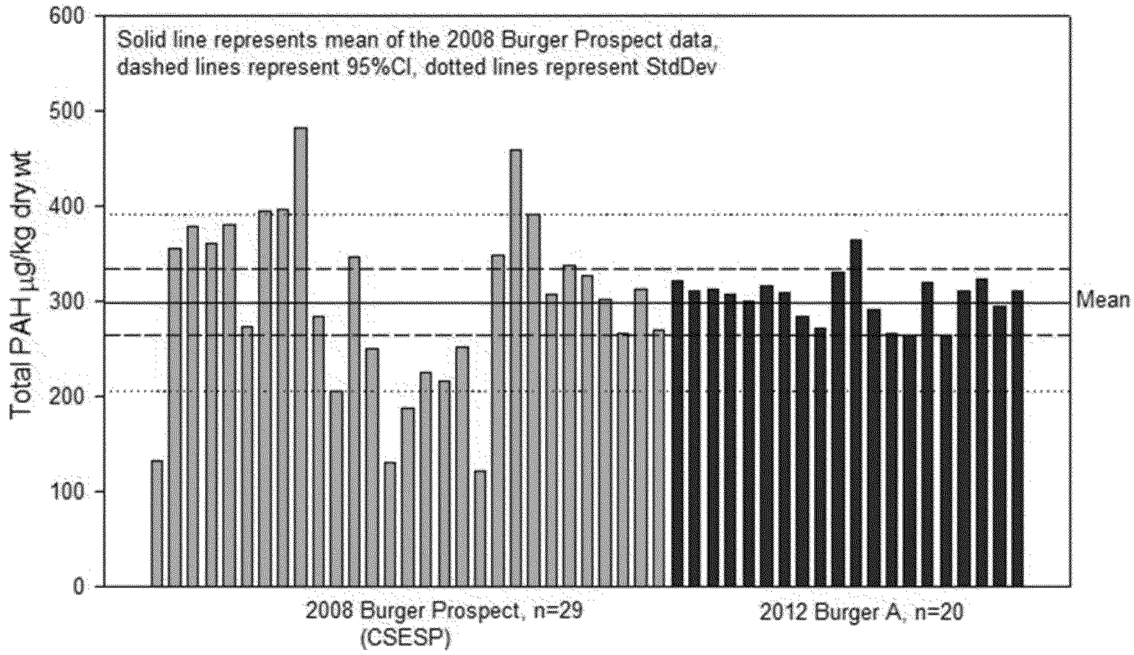


Figure 11: Total PAH concentrations (µg/kg DW) in sediment samples from the Burger Study Area (2008) and the Burger A drill site (2012) of the Chukchi Sea with the mean concentration, the 95% confidence intervals (dashed lines), and the SD (dotted lines) shown for the Burger Study Area samples.

Average sediment Total PAH concentration for 2008 Burger Study Area samples and Burger A drill site samples was 300 and 304 µg/kg DW, respectively. Variability within those two datasets was slightly greater for the Burger Study Area samples (Figure 10) than the Burger A drill site samples, with a SD of 93 µg/kg DW (Table 4) that translates to a %RSD of 30. In contrast, variability was very small for the Burger A drill site samples, which had a SD of 25 µg/kg DW (%RSD of 8%).

The data assessment also included normalizing the PAH concentrations to common data-normalizing parameters, to account for natural variability due to differences in sediment characteristics that may otherwise confound the data analysis. These sediment characteristics included using sediment TOC concentration, grain size (represented by the %fines [silt + clay]), and perylene (a non-petroleum, primarily biogenic, PAH that is abundant in some sediments). PAH concentrations in the Burger Study Area and the Burger A drill site generally covaried with all three parameters, increasing with increasing %TOC, %fines, and perylene (Figure 12). These relationships were not strong and did not indicate that these were major drivers of the hydrocarbon concentrations. The %TOC and %fines, however, may help to predict site-specific hydrocarbon concentrations. For example, the Burger Study Area TOC-normalized Total PAH concentrations were predictive of the Burger A drill site concentrations (Figure 12).

One-way analyses of variance (ANOVA) and Mann-Whitney tests were conducted on both data sets in order to compare the Burger Study Area and the Burger A drill site sample results to test for differences or similarities. As illustrated in Table 5, Total PAH concentrations in sediment samples were not significantly different between the Burger Study Area and the Burger A drill site (p = 0.879).

The data from the Burger Study Area are very similar to those from the Burger A drill site and appear to be highly predictive of baseline concentrations in the Burger A drill site (Figure 12). Mean Total PAH concentration is statistically equivalent for these two datasets (300 and 304 µg/kg DW), and the mean and confidence intervals for the Burger Study Area data generally predict the concentration range that would be expected at a specific location within the broader Study Area, such as at Burger A drill site (dashed lines in Figure 11), with few exceptions. As expected, the SD for the Burger Study Area data (dotted lines in Figure 11) covers a slightly wider range than does the confidence intervals and fully captures variation in the site-specific data. These predictions are based solely on sediment PAH concentrations and incorporate differences from varying sediment characteristics (e.g., TOC content, grain size). The prediction can be refined further by factoring in the small influence TOC content and grain size have on PAH concentrations in the Burger Study Area and Burger A drill site (Figure 12).

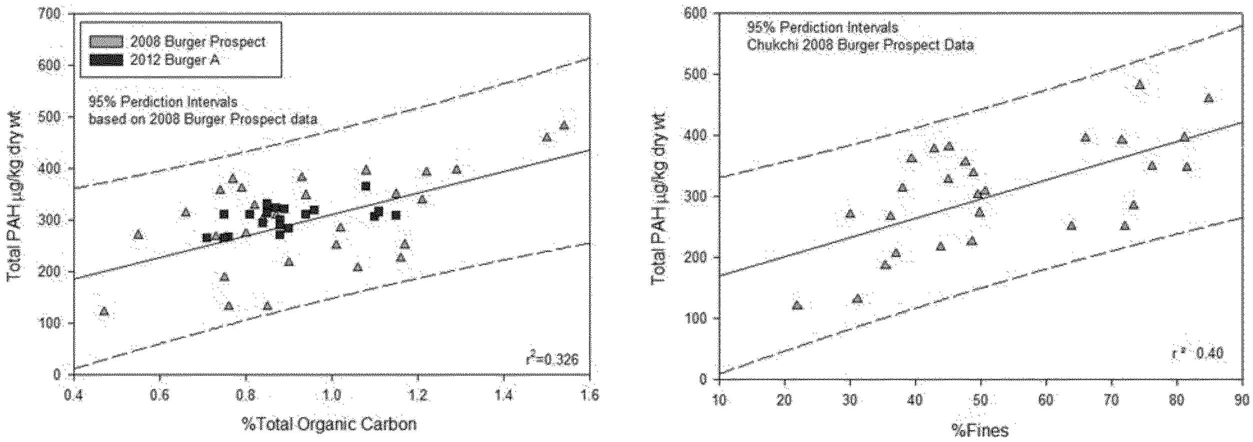


Figure 12: Total PAH concentration (µg/kg DW) vs. %TOC for the Burger Study Area (2008) and the Burger A drill site (2012) samples (top), and the Total PAH concentration (µg/kg DW) vs. % fines for the Burger Study Area (2008) samples (bottom).

Table 5: Mann-Whitney tests for difference in median concentration of PAH (µg/kg DW) in the upper 2-cm of sediments between the Burger Study Area (2008) and the Burger A drill site (2012).

	Burger Study Area (29 samples)	Burger A drill site (20 samples)		
Parameters	**Median**	**Median**	***U*-statistic**	***p*-value**
Total PAH	308	310	492	0.879

In conclusion, the recent and historical data sets have provided sufficient baseline physical site characteristics (currents, water column properties, and sediment concentrations) so that potential discharge related impacts can be evaluated at the six proposed drill sites within the Burger Prospect when combined with data collected during Phases II, III, and IV of the EMP.

3. RECEIVING WATER CHEMISTRY

Permit No.: AKG-28-8100 Part II.A.13.f.3

Receiving Water Chemistry and Characteristics. Collect water chemistry data to characterize the receiving waters. This monitoring should include an assessment of pollutants that are expected to be present in discharge effluent and for which there are federal water quality criteria and/or state water quality standards. These parameters include dissolved metals, pH, turbidity, total suspended solids, total aqueous hydrocarbons, and total aromatic hydrocarbons. The metals monitoring must include, at a minimum, the metal contaminants of concern listed in Table A, below. The permittee may propose an alternative list based on site-specific data.

The purpose of this section is to summarize available receiving water chemistry analytical results and specifically addresses natural parameters (e.g., dissolved metals, pH, total suspended solids) and potential contaminant parameters (TAH and TAqH).

3.1. Metals

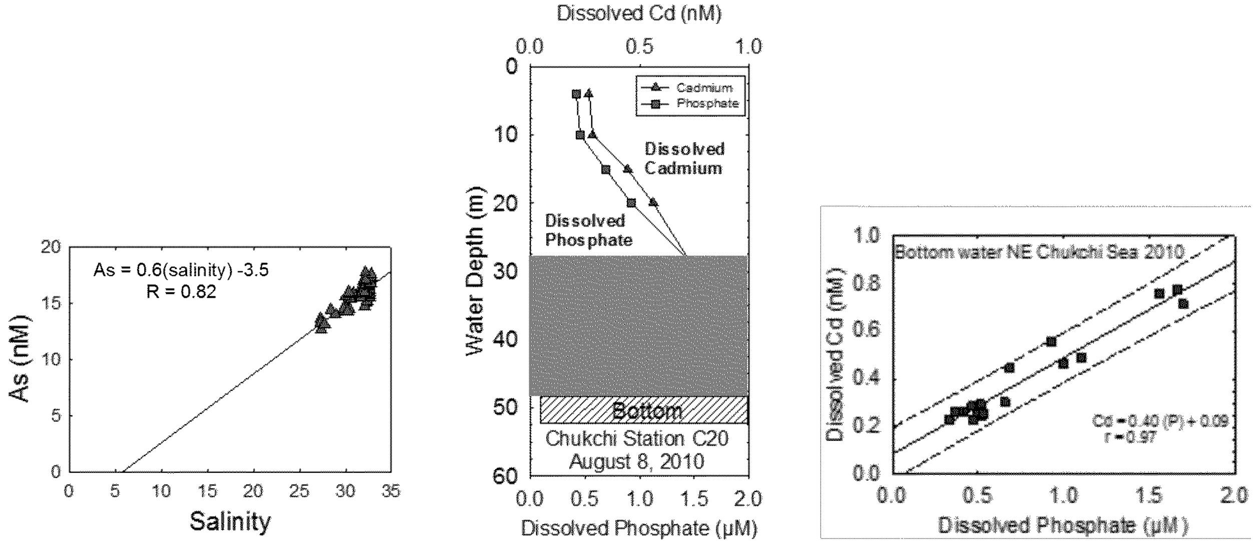
Concentrations of dissolved metals were determined for 6 samples from the Burger Study Area and 88 samples from the northeastern Chukchi Sea during 2010. The analytical results were compiled, analyzed and statistically summarized. As illustrated in Table 6, the concentrations of dissolved metals in northeastern Chukchi Sea water samples are generally consistent with Burger Study Area samples. Concentrations of some metals, including aresenic (As), barium (Ba), antimony (Sb), selenium (Se) and thallium (Tl), tend to track salinity values and have small RSD values of 3% to ~20% in both the Burger Study Area and throughout the northeastern Chukchi Sea region (Table 6 and As vs. salinity shown in Figure 13A).

Table 6: Concentrations of dissolved metals (mean ± SD) for water samples from 2010 for the Burger Study Area and northeastern Chukchi Sea as a whole.

Parameter	As	Ba	Cd	Cr	Cu	Total Hg	Ni	Pb	Sb	Se	Tl	Zn	TSS
Burger Study Area (2010; *n* = 6)													
Mean	1.16	7.7	0.046	0.13	0.24	0.0005	0.32	0.004	0.13	0.034	0.009	0.33	0.59
SD	0.04	1.2	0.024	0.07	0.04	0.0003	0.08	0.002	0.01	0.002	0.001	0.06	0.52
RSD[1]	3	16	52	54	17	60	25	50	8	6	11	18	-
Northeastern Chukchi Sea (2010; *n* = 88)													
Mean	1.15	8.2	0.046	0.10	0.27	0.0005	0.32	0.006	0.12	0.034	0.010	0.45	0.80
SD	0.12	2.0	0.021	0.02	0.10	0.0003	0.08	0.002	0.01	0.006	0.002	0.26	0.88
RSD[1]	10	24	46	20	37	60	25	33	8	18	20	58	-

metals measurements = μg/L
TSS = mg/L
[1]RSD = (SD/mean) x 100%

Inorganic nutrients, including copper (Cu), nickel (Ni) and zinc (Zn), are present in low concentrations in nutrient-depleted surface waters and are enriched due to remineralization in bottom waters (Figure 13B); therefore, concentrations of these metals correlate strongly with concentrations of nutrients (Figure 13C). Average concentrations of potential contaminants such as lead (Pb) and mercury (Hg) are very low, at <5 and 0.5 parts per trillion (ng/L), respectively.



(A) (B) (C)

Figure 13: (A) Dissolved As vs. salinity, (B) vertical profiles for dissolved phosphate and Cd, a nutrient-type metal, and (C) concentrations of dissolved Cd vs. phosphate for bottom water in the northeastern Chukchi Sea (from Dunton et al. 2012).

The existing baseline data for dissolved metals include 12 of the metals listed as required in the NPDES permit (Table A, p. 21). Seven metals (Al, Be, Fe, methyl Hg, Ag, Sn, and Ti) are not included in this data summary. To obtain this information, receiving water samples will therefore be collected during the Phase II (during drilling) component (rather than during a Phase I component) at reference stations in far-field areas located approximately 1,000 m from the drilling discharge location. These water samples will serve as contemporaneous reference samples for evaluation of receiving-water chemistry and characteristics and will be compared to the water samples collected in near-field areas during plume monitoring for metals analyses. The comparison between the near-simultaneous collection of water samples, both within and outside of the discharge plume(s), will serve as a more robust means of determining differences between elevated metals concentrations in the plume and the typical "background" metals concentrations in Chukchi Sea receiving waters. The same approach will also be used for hydrocarbon concentrations in water, discussed below.

3.2. pH, Turbidity, and Total Suspended Solids

Data on pH, turbidity and total suspended solids are well characterized in receiving waters in the Burger Study Area. pH data were collected in the Burger Study Area during the CSESP program in 2010 and 2011 (Mathis 2011). pH values were calculated from total alkalinity measurements and, for the months of August and September 2010, averaged 8.16 ± 0.08 (SD) at a water depth of 1 m, 8.18 ± 0.09 (SD) at 5 m, and 8.15 ± 0.07 (SD) at 10 m (Mathis, 2011). Turbidity and total suspended solids baseline data in the Burger Study Area and northeastern Chukchi Sea were addressed in Physical Characteristics (Section 2).

3.3. Total Aromatic Hydrocarbons and Total Aqueous Hydrocarbons

Concentrations of hydrocarbons in water typically are very low and do not provide a representative evaluation over a temporal scale. In addition, sediment and tissue concentrations (as well as source samples, such as muds and cuttings) are more applicable for monitoring and assessing impacts of hydrocarbons in the context of exploratory drilling operations. Baseline hydrocarbon concentrations from recently collected seafloor sediments and biota tissue are provided in this appendix.

Receiving water samples will therefore be collected during the Phase II (during drilling) component (rather than during a Phase I component) at reference stations in far-field areas located approximately 1,000 m from the drilling discharge location. These water samples will serve as contemporaneous reference samples for evaluation of receiving-water chemistry and characteristics and will be compared to the water samples collected in near-field areas during plume monitoring for hydrocarbon analyses. The comparison between the near-simultaneous collection of water samples, both within and outside of the discharge plume(s), will serve as a more robust means of determining differences between elevated hydrocarbon concentrations in the plume and the typical "background" hydrocarbon concentrations in Chukchi Sea receiving waters.

4. BENTHIC COMMUNITY STRUCTURE

Permit No.: AKG-28-8100 Part II.A.13.f.4

Benthic Community Structure. Describe the composition of the drilling site's benthic community (infaunal and epifaunal invertebrates, bivalves, and crustaceans).

The purpose of this section is to provide a synthesis of the available benthic ecology data and a summary of recent efforts to establish baseline bioaccumulation data for the Burger Prospect area.

4.1. Benthic Ecology Data

The ecology of benthic communities in the northeastern Chukchi Sea has been a focus of research since the 1970s. Initial research in the area by U.S. scientists was conducted by Stoker (1981), who demonstrated broad-scale trends across the Bering and Chukchi seas. Feder et al. (1994) sampled benthic communities in the northeastern Chukchi Sea in 1986, providing details on the environmental characteristics associated with benthic community structure. Later, in the early 2000s, research programs such as RUSALCA and the Shelf Basin Interactions project evaluated benthic communities from the western and northeastern Chukchi Sea and investigated ecological processes at the shelf margin (Grebmeier et al. 2006, 2009; Bluhm et al. 2009).

Localized sampling of infaunal and epifaunal communities, with the specific goal of acquiring baseline benthic community structure data, began in 2008 with the initiation of the CSESP program. In 2010 and 2011, larger-scale investigations were initiated by both the CSESP and COMIDA CAB programs (Dunton et al. 2012; Blanchard et al. In press a, b).

Overall, the CSESP sampled 26 stations for benthic infauna in the Burger Study Area annually from 2008 to 2012, and 9 stations were sampled in both 2011 and 2012. Two stations were sampled for infauna in the Burger Study Area during the COMIDA CAB program (Dunton et al. 2012). In addition, 18 baseline samples were also collected in 2012 at the Burger A drill site location. Trawling for epifauna occurred at 13 stations in the Burger Study Area from 2009 to 2010 (as part of CSESP) with two stations sampled for epifauna (as part of COMIDA CAB). These research programs have provided an important data set for understanding the biological and environmental characteristics of the Burger Prospect and the six proposed drill sites, as summarized in detail below.

The infaunal community in the Burger Study Area is dominated numerically by polychaetes and bivalves (Table 7). The maldanid polychaete worm *Maldane sarsi* is a numerically dominant organism throughout the offshore environment of the northeastern Chukchi Sea by density and biomass with extremely high densities at some sites in Burger Study Area (Feder et al. 1994; Blanchard et al. 2011, In submission a, c). The polychaete *Scoletoma* spp. and crustaceans, including ostracods and amphipods such as *Photis* spp., also occur in moderate densities. The bivalve *Ennucula tenuis* is a dominant organism by density and biomass, with larger bivalves such as *Astarte borealis* and *Macoma calcarea* and the peanut worm *Golfingia margaritacea* occurring in substantial biomass as well.

Table 7: Numerically dominant organisms (top 5) by density (individuals m^{-2}) and biomass (grams m^{-2}) for the Burger Study Area. Values are averaged from the 2008-2011 studies.

Infauna			
Taxon	**Density**	**Taxon**	**Biomass**
Maldane sarsi	1,093	*Astarte borealis*	45.7
Ostracoda	282	*Macoma calcarea*	43.7
Ennucula tenuis	203	*Golfingia Margaritacea*	40.4
Scoletoma spp.	140	*Maldane sarsi*	40.1
Photis sp.	129	*Ennucula tenuis*	28.9
Epifauna			
Common name	**Density**	**Common name**	**Biomass**
Brittle starts	86.1	Brittle starts	55.2
Snails	3.5	Snails	5.6
Sea cucumbers	3.1	Sea cucumbers	4.5
Shrimps	1.9	Crabs	3.3
Amphipods	0.5	Basket stars	2.1

The epifaunal community is dominated numerically by the brittle star *Ophiura sarsi* in the Burger Study Area and throughout many parts of the northeastern Chukchi Sea (Table 7; Bluhm et al. 2009; Blanchard et al. 2011, In press a, In press b). Sea cucumbers and snails are also dominant.

In order to evaluate community-level variation, infauna were ranked by density and biomass. In addition, comparisons of dominant organisms via station rankings can provide insights into what constitutes acceptable ranges of community variation in density and biomass within the Burger Study Area. Community-level variations among stations were evaluated by ranking infauna from the station with the lowest density versus the highest density from 2008 to 2011 (see Table 8). The rankings provided insights into communities under different environmental regimes in Burger Study Area stations, and a background for comparing other Burger drill sites. The numerically-dominant species in the stations with minimal (BF025 in 2010) and maximal (BF013 in 2011) densities reflect the overall dominants in the Burger Study Area and within the entire CSESP Study Areas (Blanchard et al. In press b). The dominant species in both stations are organisms that are found throughout the three Study Areas and that are common in soft sediments (i.e., none of the species or patterns of composition deviate from the expected patterns for the area).

Table 8: Numerically dominant organisms (top 5) by density (individuals/m²) and biomass (g/m²) for the station with the lowest and highest density values for the Burger Study Area from the 2008-2011 CSESP.

Year	Station	Taxon	Abundance	Taxon	Biomass
2010	BF025	*Macoma calcarea*	193	*Macoma calcarea*	215.44
		Cirratulidae	77	*Macoma moesta*	13.31
		Dipolydora sp.	57	*Ennucula tenuis*	12.80
		Ennucula tenuis	50	*Periploma aleuticum*	12.74
		Pholoe minuta	43	*Cyclocardia crebricostata*	6.67
		Nephtys punctate	13	*Priapulus caudatus*	0.93
2011	BF013	*Maldane sarsi*	9,443	*Neptunea heros*	107.24
		Ostracoda	1,083	*Golfingia margaritacea*	82.73
		Ennucula tenuis	550	*Ennucula tenuis*	55.40
		Photis sp.	437	*Cyclocardia crebricostata*	10.36
		Barantolla americana	230	*Musculus discors*	5.24

Therefore, benthic communities in the Burger Study Area, based on 2008-2011 data, are similar in composition to those found in prior years and within the Chukchi Sea as a whole (Feder et al. 1994; Grebmeier et al. 2006). The dominance of densities by *Ennucula tenuis* and *Maldane sarsi* and of biomass by large bivalves in 1986 and 2008-2010 demonstrates that, at least very broadly, communities have temporally persistent biological characteristics when compared with organisms listed in Feder et al. (1994).

The numerically dominant species and the benthic assemblages in general are present because of the influence of species advected into the Chukchi Sea from the north Pacific through the Bering Sea (Feder et al. 1994; Grebmeier et al. 2006; Bluhm et al. 2009; Dunton et al. 2012; Blanchard et al. In submission a and b, 2013). The northward-flowing water advects benthic larvae and organisms into the Arctic, resulting in a high similarity of communities from the Gulf of Alaska to the northeastern Chukchi Sea (Blanchard et al. In press a). Overall, the benthic community in the Burger Study Area observed throughout the multi-year sampling period (2008-2011) is a common assemblage found in soft-bottom and muddy sediments throughout Alaska.

The importance of advected water on benthic communities is now understood, with distinct benthic assemblages being strongly influenced by sediment characteristics and the nutrient characteristics of overlying water masses (Feder et al. 1994; Grebmeier et al. 2006). Associations between environmental characteristics and benthic communities are due to the covariance of sediment characteristics and faunal communities with water circulation. Of particular importance for the Burger Prospect Area is the understanding that increased benthic productivity is more apparent in areas with altered water circulation (e.g., points, shoals and canyons) (Feder et al. 1994, 2007; Grebmeier et al. 2006), indicating the importance of local-scale processes as controls on benthic communities (Blanchard et al. In press a, In press b; Weingartner et al. In press).

4.2. Are the data from the CSESP program adequate to serve as baseline site characterization data for post-drilling monitoring at prospects?

The multi-year CSESP data from the Burger Study Area were compared to the Burger A-specific data from 2012 in order to answer the following question: "Are the data from the CSESP program adequate to serve as a baseline for post-drilling monitoring at prospects?" To answer this question, data were compared using faunal rankings and regression analysis to determine whether results from the Burger A drill site location fall within the trends observed in the data sets from the Burger Study Area as a whole. Because laboratory analyses for the 2012 Burger A drill site sampling are still in process (only 1 replicate has been completed at all stations), some differences will be apparent in the comparisons due to lower within-station diversity. Data are therefore averaged across all stations to determine average faunal densities for the Burger A drill site.

Data from three replicate samples collected at each station indicate that the greatest difference between the Burger A drill site overall and the Burger Study Area stations is that the numbers of *Maldane sarsi* in the Burger A drill site are low (Table 9). Densities of *M. sarsi* in the Burger Study Area ranged from an average of 3 to 9,500 individuals m^{-2} at some stations, whereas preliminary densities from the 2012 sampling at Burger A ranged from 10 to 70 individuals m^{-2}. Overall, densities appear to be toward the low end of the range. The remaining numerically dominant organisms at the Burger A drill site, however, also were found throughout the Burger Study Area. The location-specific community, however, fits well within the community-level variability observed within the Burger Study Area stations (Tables 7 and 8). The similarity of the stations is indicated by the consistent presence of key dominants throughout the drilling location including *Barantolla americana, Ennucula tenuis, Golfingia margaritacea, Macoma calcarea* and *Maldane sarsi,* all of which are found in Burger A drill site stations.

Table 9: Numerically dominant organisms (top 5) by density (individuals m^{-2}) and biomass (g m^{-2}) for the Burger A drill site. Values are averaged from 18 stations sampled at Burger A drill site in 2012. The density and biomass of *Maldane sarsi* also are presented, although they are not in the top 5 in either category.

Taxon	Density	Taxon	Biomass
Ostracoda	276	*Golfingia margaritacea*	87.6
Ennucula tenuis	202	*Macoma calcarea*	62.7
Barantolla americana	99	*Ennucula tenuis*	22.6
Ektondiastylis robusta	79	*Ophiura sarsi*	11.7
Terebellides stroemi	66	*Paradiopatra parva*	5.5
Maldane sarsi	31	*Maldane sarsi*	2.6

Community characteristics of the Burger A drill site were also evaluated with regression analysis. Total infaunal density and biomass for the Burger Study Area stations from the 2008-2011 CSESP (the 2012 data are not yet processed) and the Burger A drill site from the 2012 DMP were regressed against percent mud (see Figure 14). The biological data were *ln*-transformed to address statistical assumptions. The relationships between percent mud and the biological variables are weak, with R^2 accounting for 10% of the total variability in infaunal density and only 3% of total variability for biomass. (Low R^2 values are not uncommon when considering a single variable in benthic studies and can be improved dramatically with the addition of other covariates.)

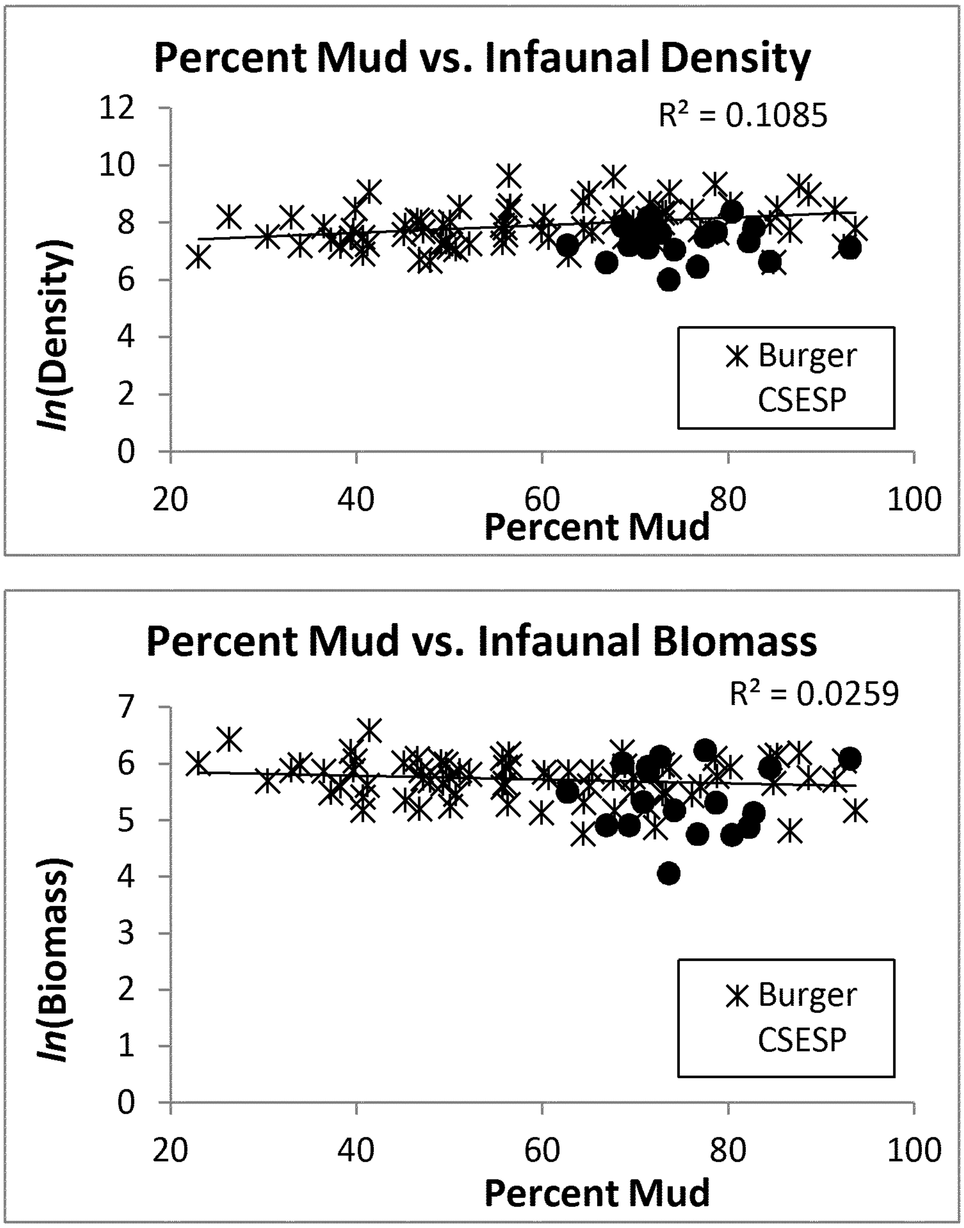


Figure 14: Percent mud regressed against *ln*-transformed infaunal density and biomass data from the 2011 CSESP study of the Burger Study Area and Burger A drill site samples from 2012 (DMP).

These relationships demonstrate that the baseline samples collected at Burger A drill site in 2012 are consistent with the ranges measured for the Burger Study Area stations as a whole. Although more muddy than most stations, the Burger A stations fall well within the boundaries of the regression, based on the other Burger Study Area stations. It is also to be expected that the differences seen may be due to micro-scale deviations in environmental conditions.

In conclusion, although the preliminary community structure does vary somewhat from that expected for the Burger Study Area due to low numbers of *M. sarsi* (Tables 7 and 8 vs. Table 9), the benthic community structure falls within the general trends identified at the Burger Study Area. The regression and faunal ranking data clearly demonstrate that the benthic community structure at the Burger A drill site is representative of the community structure gradients in Burger Study Area and can be consider as sufficient baseline site characterization data for the six proposed drill site locations within the Burger Prospect.

4.3. Bioaccumulation Data

Bioaccumulation monitoring is a required component of Phase I baseline site characterization for operators that plan to discharge water-based drilling fluids and drill cuttings (Discharge 001).

Bioaccumulation is the uptake of chemicals over time in an organism. Coastal monitoring programs have existed in the U.S. for many decades (e.g., the "Mussel Watch Program," U.S. National Status and Trends Program) and primarily have used clams (or bivalves) to measure the bioaccumulation of various persistent organic pollutants such as PAHs, polychlorinated biphenyls (PCBs), and pesticides such as dichlorodiphenyltrichloroethane (DDT) (Gunther et al 1999). Bioaccumulation of metals historically has also been monitored by using immobile, sentinel clams (or bivalves). For example, mussels and oysters have been used for such purposes in the U.S. National Status and Trends Program from 1986 to present (Kimbrough et al. 2008).

Clams are often used because they are an important indicator animal for monitoring contaminants in the environment. Clams are sessile and useful for conservatively assessing bioaccumulation potential. They effectively accumulate bioavailable contaminants such as PAHs and do not readily metabolize or excrete such compounds like many other animals do. By measuring the chemical body burden in the tissues of organisms that do not readily metabolize the compounds of interest, a measurement of the amount of compound that is bioavailable (i.e., actually taken up by the organism) in the water or sediment can be gained. By examining organisms at the lower level of the food chain (e.g., clams or bivalves), a greater understanding can be gained of the magnitude of chemical concentration through the food web. The simplest way to measure bioaccumulation is to determine the concentrations of chemicals of interest in the organisms of interest and compare these concentrations to sediment concentrations.

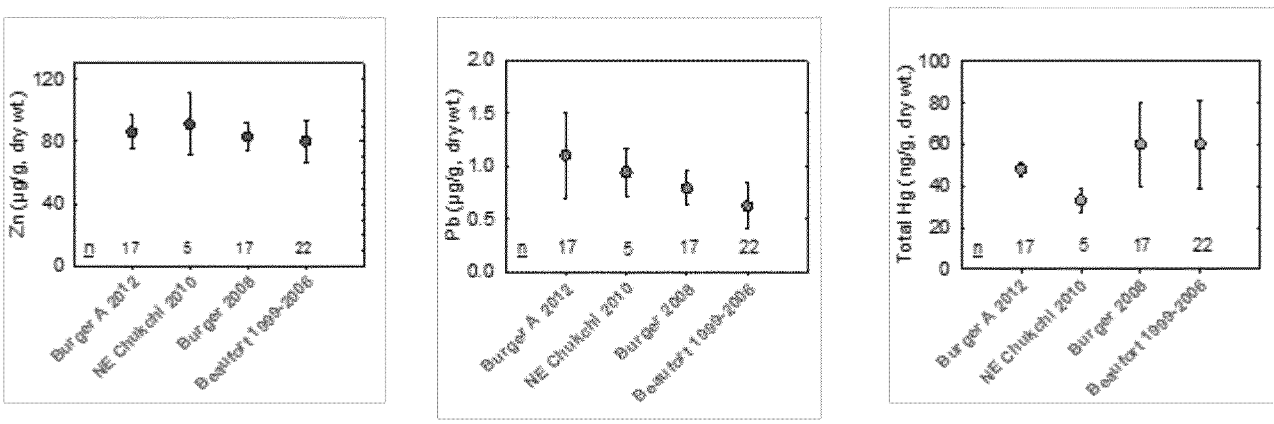
Typically, biota-sediment accumulation factors (BSAFs) are a good gauge of bioaccumulation for hydrophobic organic contaminants in sediment-dwelling (i.e., benthic) species such as clams. As part of the EMP Phases III and IV, bioaccumulation will be assessed by measuring contaminant concentrations in two different environmental compartments (sediment and biota) and calculating BSAF values. Once calculated, these values can be compared to baseline (Phase I) data and Phase III and IV data to determine whether bioaccumulation of particular chemicals has increased as a result of drilling operations. Bioavailability of these compounds is also indirectly measured using BSAF calculations because only the freely dissolved fraction will be available for uptake into the organism (particularly in filter-feeding species such as clams. Depuration on-vessel will aid in limiting sediment gut contributions to total chemical concentrations). BSAF values are calculated by dividing the lipid-normalized tissue concentration of a particular analyte by the organic carbon-normalized sediment concentration of the same analyte. BSAF values less than 1 typically indicate a particular compound is not fully bioavailable to the organism evaluated. This concept is appropriate for hydrophobic organic chemicals (e.g., PAHs).

It is important to note that significant issues exist for collection of clams in the Chukchi Sea due to natural patchiness in abundance, challenges with obtaining sufficient tissue mass for laboratory chemical analysis, difficulty with collecting tissue samples of identical species, and gut contributions to body-burden measurements. Furthermore, chemical concentrations in biota are typically more variable than those in sediments. As such, these data are not as effective at demonstrating moderate changes in chemical concentrations due to anthropogenic impacts. Every effort will be made to collect clams in the field; however, the challenges must be acknowledged.

Provided below is a summary of the available baseline bioaccumulation data for the Burger Prospect.

4.3.1. Metals

Clams (*Astarte* spp.) have been used for monitoring bioaccumulation in the Chukchi and Beaufort seas (e.g., Neff et al. 2009, 2010; Dunton et al. 2012). Metal concentrations in clams collected during 2012 from the Burger A drill site were highly variable, with an average RSD of 39% (Table 10). Zinc, which is an essential element for clams, is regulated biochemically by Zn-bearing enzymes; consequently, variations in clam Zn concentrations (RSD = 12%) were smaller than observed for some non-essential metals such as Cd, Pb and Sn (Table 10 and Figure 15 for Zn, Pb and Hg).



(A) **(B)** **(C)**

Figure 15: Means (marker) ± SDs (lines) for concentrations of (A) Zn, (B) Pb, and (C) total Hg for clams (*Astarte* spp.) from Burger A drill site and other areas in the northeast Chukchi Sea and the Beaufort Sea (*n* = number of samples).

Table 10: Concentrations of metals (mean ± SD) for clam (*Astarte* spp.) samples from 2012 for Burger A drill site and other northeast Chukchi Sea locations.

Parameter	Ag (µg/g)	As (µg/g)	Ba (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (%)	Total Hg (ng/g)
Burger A drill site (2012) (*n* = 18)								
Mean	0.26	13.1	21.6	13.5	1.3	15.3	2200	48
SD	0.11	4.3	4.5	13.1	0.4	2.2	746	3
RSD[1]	42	33	21	98	31	14	34	6
Burger Study Area and NE Chukchi Sea (2008, 2010, *n* = 20)								
Mean	0.22	11.8	14.2	34	1.3	9.6	1400	49
SD	0.16	1.4	9.6	12	0.3	2.5	770	19
RSD[1]	72	12	68	36	22	26	55	40

Parameter	MeHg (ng/g)	Ni (µg/g)	Pb (µg/g)	Se (µg/g)	Sn (µg/g)	V (µg/g)	Zn (µg/g)
Burger A drill site (2012, *n* = 18)							
Mean	7	5.6	1.1	4.2	0.14	5.7	86
SD	2	3.3	0.4	1.3	0.11	2.6	10
RSD[1]	33	58	39	30	83	46	12
Burger Study Area and NE Chukchi Sea (2008, 2010, *n* = 20)							
Mean	10	-	0.7	8.4	-	3.4	83
SD	2	-	0.1	1.5	-	2.2	11
RSD[1]	19	-	12	18	-	65	14

[1]RSD = (SD/mean) x 100%.

Metal data for clams from Burger A drill site (Table 10) provide a suitable baseline for identifying future assessment of metal contamination in biota. Overall metal concentrations in clams from the Burger A drill site are consistent with results for other locations in the Burger Study Area and throughout the northeast Chukchi Sea. The existing data from Burger A drill site and throughout the northeast Chukchi Sea, therefore, provide a suitable and valuable baseline for metals in clams from other locations in the northeast Chukchi Sea, including other Burger drill sites. As has been noted for the U.S. National Status and Trends Program, observed natural variations in metal concentrations in bivalves limit the sensitivity of identifying increased values due to contamination; however, marked metal contamination would still be discernible in these *Astarte* clams from the northeast Chukchi Sea.

4.3.2. Hydrocarbons

Two data sets on PAH chemistry in biological tissues from the Chukchi Sea were used to determine if sufficient baseline information exists for site-specific locations in the Burger Study Area. The samples were collected from the same two general areas as the samples used for the sediment Total PAH analyses discussed in Section 2 (i.e, samples from the Burger Study Area collected in 2008 and samples collected at the Burger A drill site in 2012). The data analysis presented here also focused on polycyclic aromatic hydrocarbon (PAH) concentrations in clams. PAHs were used to represent potential hydrocarbon contaminants because they are the class of analytes that are of greatest interest from a bioaccumulation and environmentally relevant perspective.

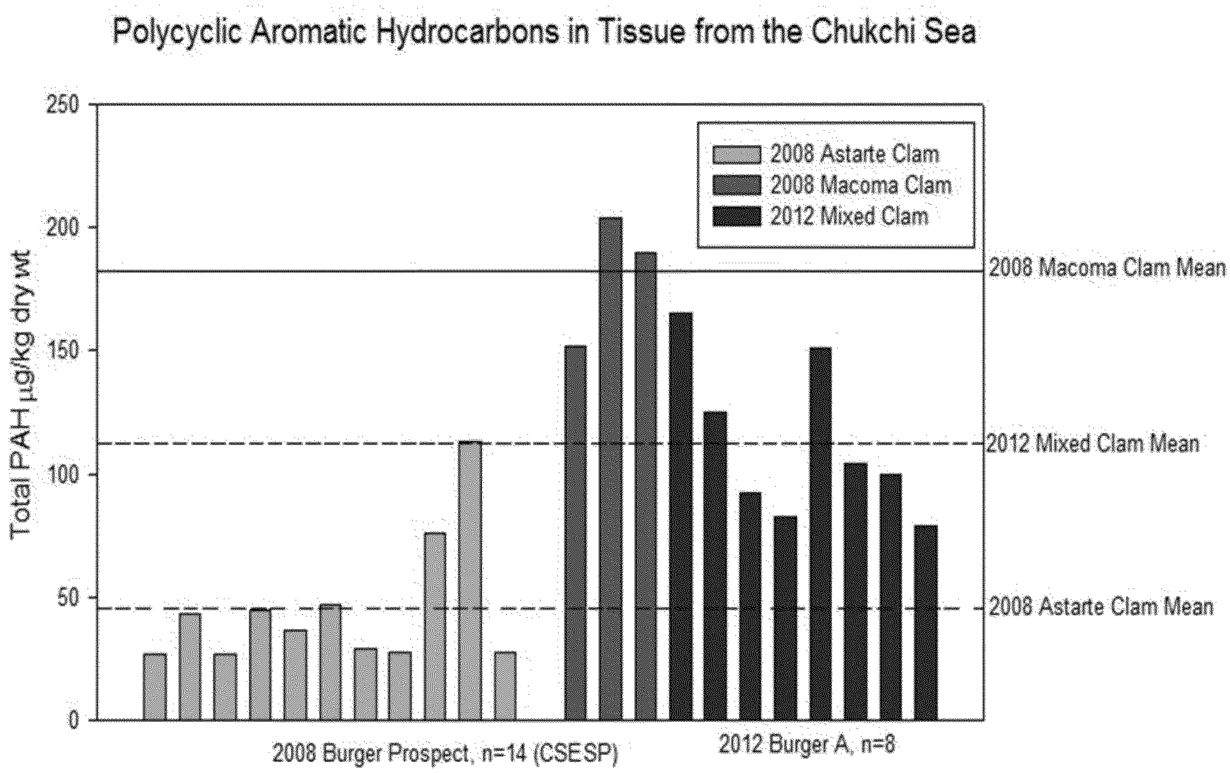
The Burger Study Area data set consisted of 11 *Astarte* spp. clam samples and three *Macoma* spp. clam samples collected in 2008. The Burger A drill site samples collected in 2012 consisted of 8 samples of a mixture of clam species. The PAH analytical results for the two Chukchi Sea datasets are summarized statistically in tables 11 and 12: Table 11 shows the data on a DW basis; Table 12 shows the data on a lipid-normalized basis. Mean Total PAH concentrations are presented along with the SD, 95% confidence interval (CI), and the Min and Max sample concentrations. These data also are presented graphically in Figure 16.

Table 11: Total PAH concentration (µg/g DW) in clams collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012.

Study Area	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger Study Area	*Astarte* clam	11	45.	26.	18.	26.	11
	Macoma clam	3	18	26.	66.	15	20
2012 Burger A drill site	Mixed clam	8	11	31.	26.	79.	16

Table 12: Total PAH concentration (µg/g lipid) in clams collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012.

Study area	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger Study Area	*Astarte* clam	11	3.8	2.9	2.0	1.6	12.0
	Macoma clam	3	4.8	1.2	3.1	3.4	5.8
2012 Burger A drill site	Mixed clam	8	4.3	0.6	0.5	3.6	5.0



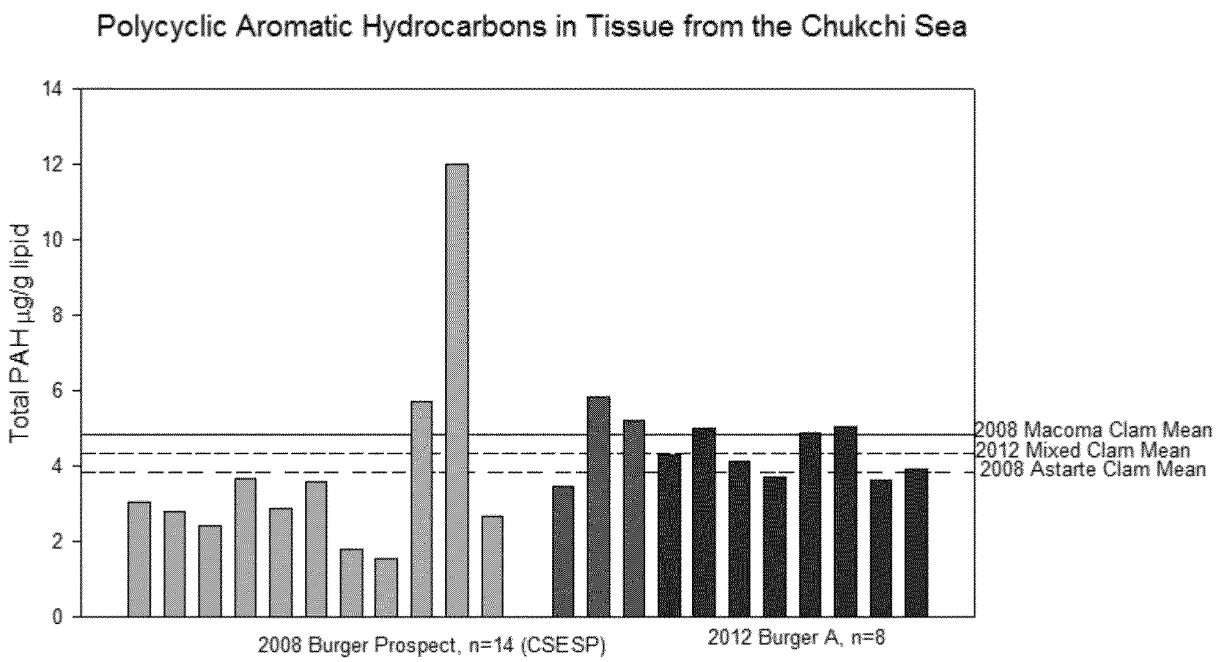


Figure 16: Total PAH concentrations in Chukchi clam samples from the Burger Study Area and Burger A drill site. Concentrations are in µg/kg DW (top) and µg/g lipid (bottom).

Average clam-tissue Total PAH concentrations for the 2008 Burger Study Area CSESP samples were 45.3 and 182 µg/kg DW for the *Astarte* and *Macoma* clams, respectively. The average Total PAH concentration was 113 µg/kg DW for the mixed-clam samples collected from Burger A drill site in 2012. There was clearly a large difference in mean PAH concentration between the two species; but, the variability within a species and the difference between the species was quite small once the data were lipid-normalized (Table 13 and Figure 16 [bottom]). The lipid content of the *Macoma* clam samples (which had the highest PAH concentrations on a DW basis) averaged 3.85%, and the average lipid content for the *Astarte* clams was 1.20%. It is clear that lipid content drives the accumulation of PAH in these clam samples. The Total PAH concentration strongly co-varied with the amount of lipid in the sample (Figure 17), as can be expected for bioaccumulation of most hydrophobic organic compounds.

Table 13: Total PAH concentration (µg/g lipid) in clams collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012.

Study	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger Study Area	Mixed clam	14	4.0	2.7	1.5	1.6	12.0
2012 Burger A drill site	Mixed clam	8	4.3	0.6	0.5	3.6	5.0

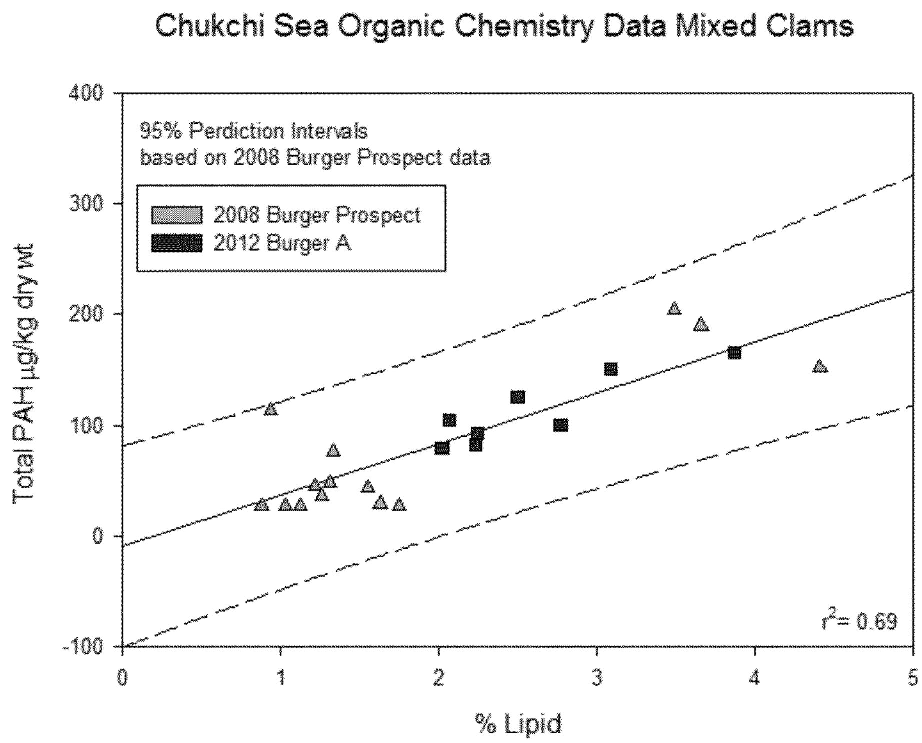


Figure 17: Total PAH concentration (µg/kg DW) vs. %Lipid for the Burger Study Area (2008) and the Burger A drill site (2012) and clam tissue samples.

Normalizing the data to the lipid content for the most part removed the influence that the specific clam species had on the data, and the *Astarte* and *Macoma* clam data could be combined for subsequent data analysis (Table 14 and Figure 18). Combining the data also made it possible to compare the 2008 and 2012 data with confidence because the 2012 samples were a mixture of species (e.g., *Astarte*, *Macoma*, and possibly other).

Table 14: Mann-Whitney tests of data for clam tissue collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012. Data for the 2008 *Astarte* and *Macoma* clams are combined (the 2012 clam samples consisted of mixed clam species).

	Burger Study Area 2008, *n*=14	Burger A drill site 2012, *n*=8		
Parameter and Concentration Basis	**Median**	**Median**	***U*-statistic**	***p*-value**
Total PAH (µg/kg DW)	44.0	102		
Total PAH (µg/kg lipid)	3.20	4.20	115	0.125

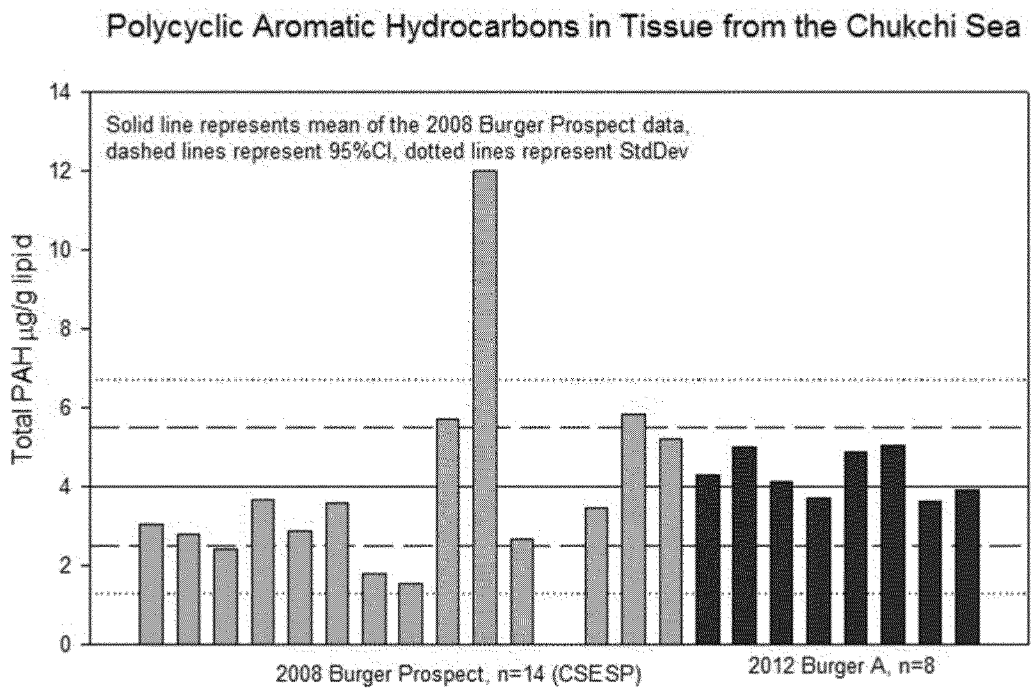


Figure 18: The Total PAH concentrations in Chukchi clam samples from the Burger Study Area and Burger A drill site. Concentrations are in µg/g lipid with the mean concentration, the 95% confidence intervals (dashed lines), and the SD (dotted lines) for the Burger Study Area data.

ANOVA and Mann-Whitney tests were also performed on both data sets, comparing them with each other to assess whether they differed (Table 14). The Total PAH (lipid-normalized) concentrations were not significantly different for samples collected in the Burger Study Area and in the Burger A drill site (p= 0.125).

The lipid-normalized data from across the Burger Study Area (the 2008 CSESP data) are very similar to the 2012 Burger A drill site data and appear to be highly predictive of site-specific Total PAH concentrations in clams collected anywhere within the Burger Study Area (Figure 18). The mean Total PAH concentration is statistically equivalent for these two Study Areas. The mean and confidence intervals for the Burger Study Area data predict the concentration range that would be expected at a specific site, such as Burger A drill site (dashed lines in Figure 18). The 95% prediction intervals for Total PAH concentration vs. %Lipid relationship is also highly predictive of the PAH concentration.

The data in Figure 17 suggest that most of the samples from 2012 are a mixture of *Astarte* and *Macoma* clams and possibly other species. The light blue triangles for the 2008 samples (%Lipid ~1-2%) are the *Astarte* clams, while the light blue triangles (%Lipid ~4%) are the *Macoma* clams. The dark blue squares represent the mixed clam samples collected in 2012, and those fall in between, suggesting that they may be a combination of mostly *Astarte* and *Macoma* because those are the most abundant clams in this area. The exception is the dark blue square towards the right (near 4%Lipid), which clusters with the 2008 *Macoma* samples, suggesting that 2012 sample may have been primarily composed of *Macoma* clams.

In conclusion, the baseline bioacccumulation data presented here are considered sufficient site-specific information to meet the EMP Phase I baseline data requirements for the six currently planned drill site locations within the Burger Prospect.

CONCLUSION

By intensively studying specific areas such as the CSESP Burger Study Area, and then evaluating these findings with the results from other larger-scale investigations such as COMIDA CAB, several insights into the northeastern Chukchi Sea marine ecosystem processes have been developed. It is now generally accepted, for example, that the presence of distinct benthic community structures in the northeastern Chukchi Sea is clearly based on several interrelated oceanographic factors, including seafloor topography (water depth), large- and small-scale ocean currents, sediment characteristics, water column properties (receiving water chemistry), and food availability (Stoker 1981, Feder et al. 1994, Grebmeier et al. 2006, Bluhm et al. 2009, Dunton et al. 2012, Blanchard et al 2011, 2013, In press a, In press b, Ravelo In press, and Day In press).

Due to its location within the northeastern Chukchi Sea, the location known as the Burger Study Area exhibits homogeneous physical and ecological conditions and should therefore be considered as a distinct location with predictable water column, sediment composition and benthic community structure (even when considering seasonal and intra-annual variations). Specifically, the distinctive interaction between seafloor topography, persistent ocean currents, and the effects of seasonal water masses, as described in detail throughout this document, explains why the Burger location has a homogeneous benthic community structure and why it is physically and biologically different from more southern areas of the northeastern Chukchi Sea region.

To date, the environmental data collected in the immediate vicinity of the Burger A drill site as well as data collected from the larger Burger Study Area confirm that a benthic-dominated trophic system exists in the Burger Prospect. It can be confidently described as a system that has less oceanic zooplankton (with presumably lower grazing capacity on phytoplankton blooms), a higher percentage of finer grained (mud) sediments (suggesting that bottom currents are not strong enough to wash away much of the mud), higher densities and biomass of benthic macrofauna and megafauna, and higher densities of benthic-feeding seals and walruses (Day et al. 2013). Due to the persistence of cold winter water, predation on benthic organisms is primarly by epibenthic invertebrates such as crabs, shrimp, brittle stars and benthic-feeding bearded seals and walruses.

As indicated by numerous discipline-specific analyses, the Burger area benthic community structure has been well characterized with respect to the local oceanographic conditions, including sediment type and composition (Weingartner et al. in press; Blanchard et al. 2011; Blanchard et al. 2013; Trefry et al. 2012; Blanchard and Feder in press; and Blanchard et al. in press). Researchers associated with the COMIDA CAB project have also investigated the spatial and temporal variability in benthic community structure (composition, abundance, and biomass) and shown that it is clearly influenced by physical environmental drivers or variables such as the flow and temperature of water masses, sediment characteristics such as grain size, and food availability (Dunton et al. 2012, Konar et al. 2013; Ravelo et al. in press). It is these well studied relationships that have provided the basis for comparing between different scales of sampling.

The goal of this document has been to present and demonstrate that sufficient Phase I site characterization data exist in the vicinity of the six proposed drill sites; more importantly, that this information is sufficiently representative of existing conditions at the Burger Prospect so that Shell and EPA will be able to evaluate and assess potential impacts from authorized discharges. As presented in Sections 1 through 4, multiple comparisons of physical and biological data from the broader Burger Study Area to the Burger A drill site indicates that it is reasonable and sufficient to utilize the available Prospect-level data as site characterization data at the six proposed drill site locations. In the case of the seven dissolved metals and hydrocarbon concentrations in water that are not available for baseline information, the collection of these data has been addressed and will be conducted during Phase II monitoring at contemporaneous reference stations. The absence of these water concentrations does not weaken the conclusion that the already existing baseline information in the northeastern Chukchi Sea are sufficient to serve as Phase I baseline data.

The conclusions presented in this document are based on the compilation and analysis of site characterization data from the previous five years. The data analyses, including statistical comparisons, were conducted to determine the variability within and among the data sets from the same region and to demonstrate that historical data from a larger encompassing area is sufficiently representative of "pre-drilling" conditions for impact assessment purposes. This conclusion is especially valid when it is recognized that reference or far-field sampling (i.e., control samples) for water, sediment, and biota will be an integral part of the scientific sampling protocol (Phases II, III, and IV) described in the EMP Plan of Study.

In summary, recent data demonstrate that the baseline at Burger Study Area has been characterized for the 1) initial site physical sea bottom survey; 2) physical characteristics; 3) receiving water chemistry and characteristics (with the exception of hydrocarbons, which will be included in the EMP), and 4) benthic community structure. These existing data are sufficient to serve as Phase I baseline site characterization data, as per the Chukchi Sea General Permit, and meet the Phase I data collection requirements.

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ATTACHMENT A

Burger A Pre-Drill Sediment Profile Imaging Survey

APPENDIX B

Particulate Modeling Report

APPENDIX C

Thermal Modeling Report